POWER PLANT ENGINEERING

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Power for Toasting Cornflakes

DIVERS POWER REQUIREMENTS AT THE KELLOGG TOASTED CORNFLAKE FACTORY SUCCESSFULLY MET BY AN EFFICIENTLY OPERATED POWER PLANT

OF THE MANY thousands of individuals throughout the country who start the day off with an appetizing bowl of golden browned toasted cornflakes there are probably few who give any thought as to the power required to impart to the flakes their golden brown color. Considered singly, a cornflake does not require a great amount of heat energy to toast it, but when millions of them are considered collectively the toasting problem presents itself in an entirely different aspect.

At the plant of the Kellogg Toasted Cornflake Co. at Battle Creek, Mich., where millions of cornflakes are toasted hourly, the toasting ovens require the production of some 3,000,000 cu. ft. of gas per day. Many other food products besides cornflakes are produced in this big sunlit factory, however, and power is used for numerous purposes other than toasting. This extensive use of power obviously requires a power plant of no small dimensions, and it is therefore not surprising to learn that the plant in question consumes in the neighborhood of 130 tons of coal a day.

Under all normal conditions, the plant is capable of carrying the entire factory load; but at times of heavy load, additional power is required. Provision has, therefore, been made for taking current from the lines of the local public service company as will be explained later.

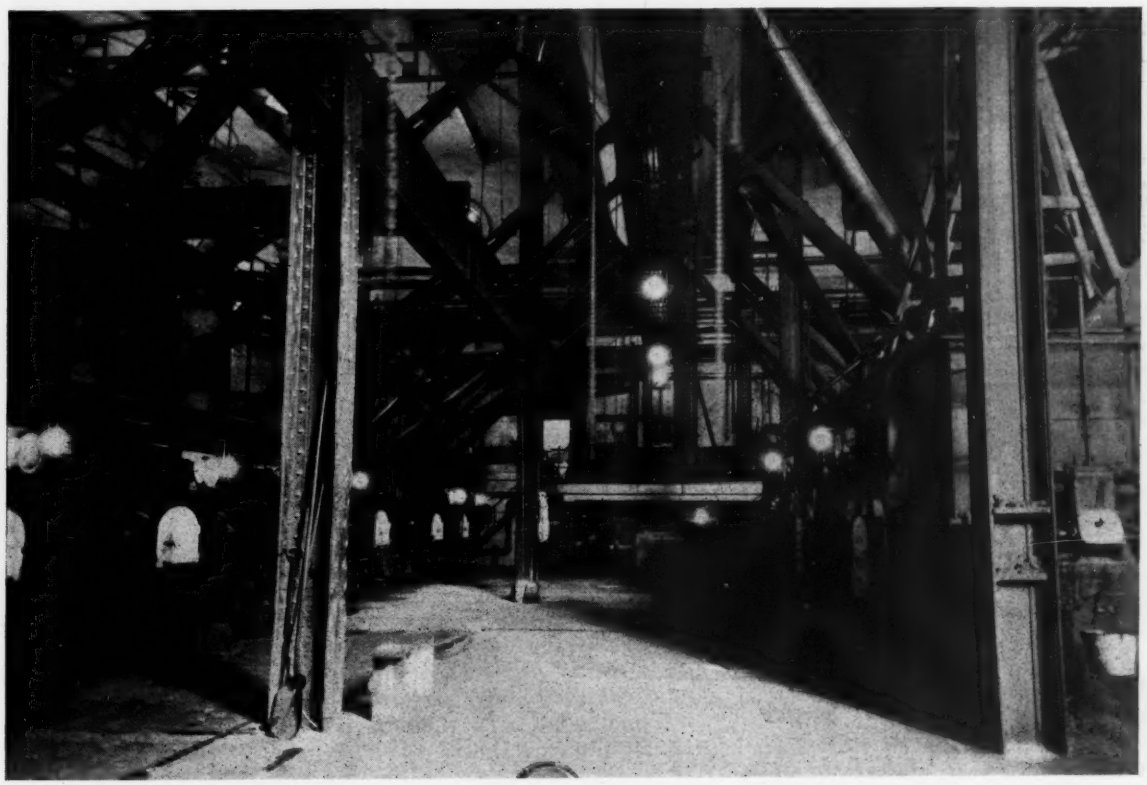


FIG. 1. BOILER ROOM AT THE KELLOGG TOASTED CORN FLAKE CO.

Throughout the 14 yr. of its existence, this plant has had to keep up with the growth of the factory which it serves and as this growth has been considerable, the power plant, in its endeavor to keep pace, has undergone many alterations due to successive increases in capacity. In spite of this fact, however, the arrangement of the plant today is as orderly and possesses all the characteristics of a strictly modern installation. As regards appearance and design, the plant compares favorably with plants of the same type erected within the past 5 yr. It has been the aim of J. D. Robertson, superintendent of power, to keep the plant up-to-date with red pressed brick. The plant is amply lighted by large windows and at night illumination is effected by incandescent lighting units suspended from the roof trusses.

Factory Requirements

It is common practice in plants serving factories of this type to have a steam generating capacity in excess of that needed by the electric generating units. This is due to the fact that a large amount of live steam is required in the factory for cooking purposes and other process work. At the Kellogg plant, approximately 55,000 lb. of live steam per hour is used in this manner.

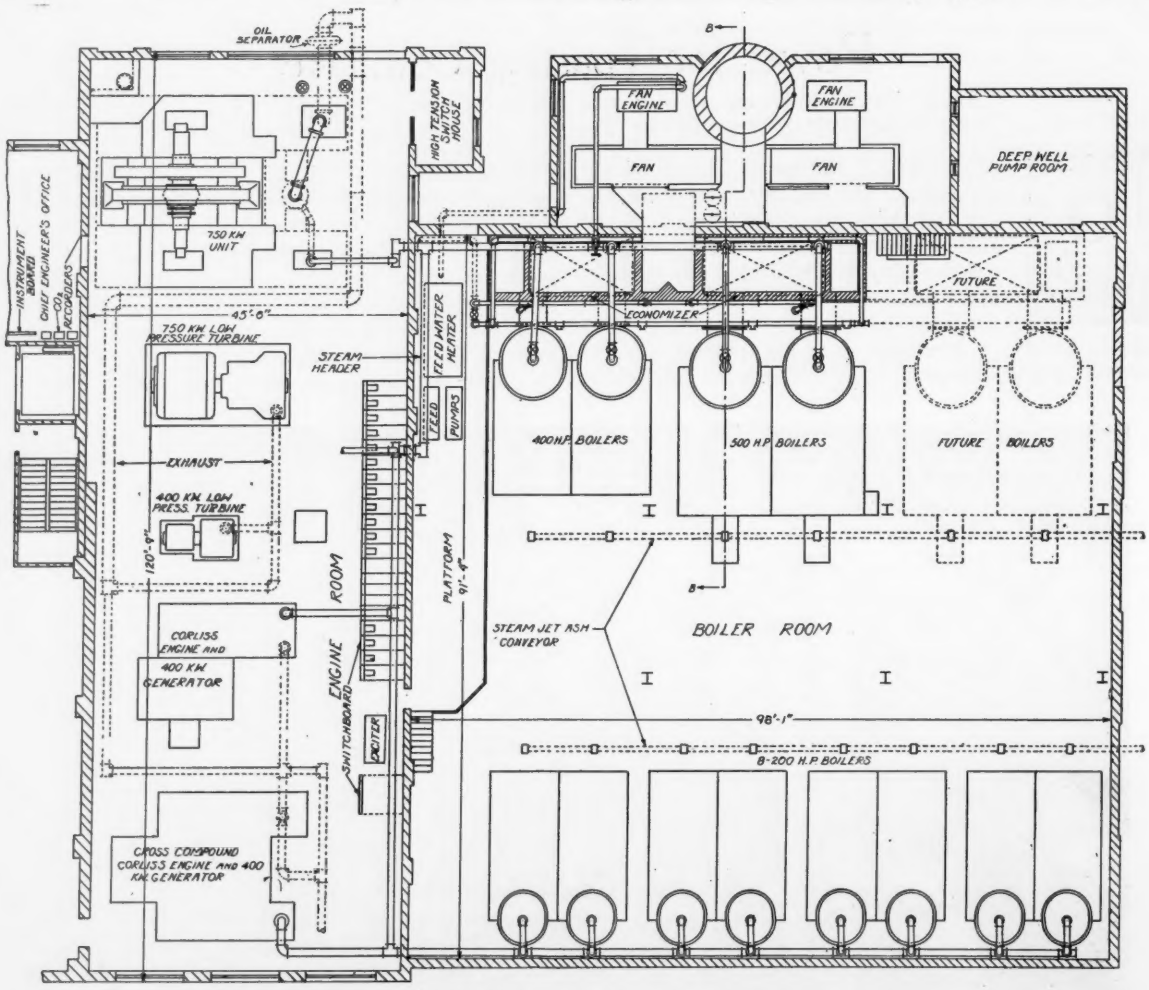


FIG. 2. ARRANGEMENT OF BOILER AND ENGINE ROOM

and to adapt it especially to the service for which it was intended. That, of course, is true of any isolated plant—it must conform to the needs of the factory it serves. Efficiency is Mr. Robertson's byword, and a systematic check is kept on every operation in the plant in order to determine where improvements may be made and where to install new equipment.

The plant consists principally of a boiler room, engine room, gas-producer room, fan and pump room, together with a spray pond for cooling condenser water.

The design of the buildings is in accordance with the design of those comprising the factory group, all being of brick and steel construction with the exteriors faced

The entire factory is heated by exhaust steam from the engines, the heating system comprising some 40,000 sq. ft. of direct radiation. Both live and exhaust steam are also used in various drying processes.

Electric energy is supplied for power, lighting and heating purposes. The power load consists of over 900 motors (mostly induction motors) of varying sizes, while the heating load consists of a large number of resistance type heating plates in the packing and sealing rooms.

As was stated previously, gas to the amount of 3,300,000 cu. ft. daily is required for heating the large

batteries of revolving toasting ovens located in the corn-flake factory.

A considerable amount of water is required in the factory for cooling and condensing purposes which, after serving its purpose in the factory, is used for condensing purposes in the power plant.

Compressed air used throughout for cleaning machinery is supplied at 80 lb. pressure by a 75-ft., 10 by 12-in. steam-driven compressor.

In addition to the foregoing power demands, a small amount of refrigeration is required for cooling drinking

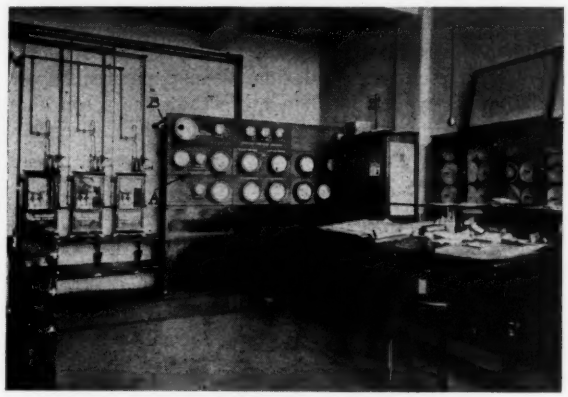


FIG. 3. CHIEF ENGINEER'S OFFICE, SHOWING INSTRUMENTS

water and for cooling purposes in the employes' restaurant. This is furnished by a 20-ton, 9 by 18-in. motor-driven ice machine employing the chloride brine system of cooling.

The Boiler Room

THE BOILER room, an interior view of which is shown in Fig. 1, is a building 100 ft. long by 94 ft. in width, containing two rows of boilers with the firing aisle in the center. Although provision is made for an ultimate capacity of 14 boilers, the plant at the present time contains 12 vertical water-tube boilers arranged eight on one side of the room and six on the other. As indicated on the plan view, Fig. 2, the 12 boilers are rated as follows: eight 200 hp., two 400 hp., and two 500 hp. They are enclosed in brick settings and fitted with furnaces of the dutch oven type, equipped with automatic overfeed stokers. Coal is delivered from the overhead bunkers directly into the tops of the furnaces, through inclined downspouts.

All boilers are equipped with economizers; induced draft being furnished by two fans as shown in Fig. 2.

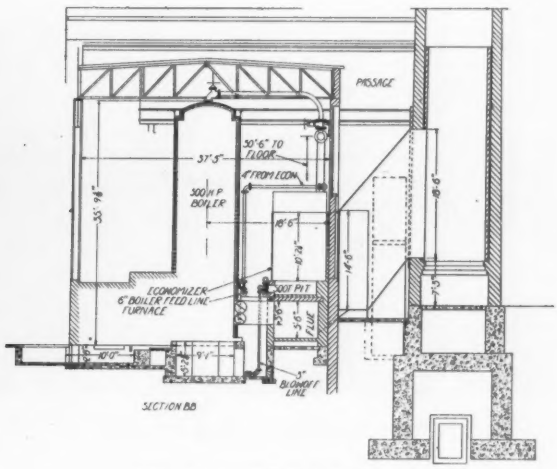


FIG. 5. SECTION B-B, FIG. 2

These fans as may be seen are installed in a fan room adjacent to the boiler room, and are driven by two slow-speed reciprocating engines, one a 10 by 12-in. and the other a 13 by 16-in., to which they are direct connected.

After passing through the economizers, the gases of combustion are removed by a radial brick chimney, 150 ft. in height. Another similar stack is to be installed in the near future, the foundation for which has already been set.

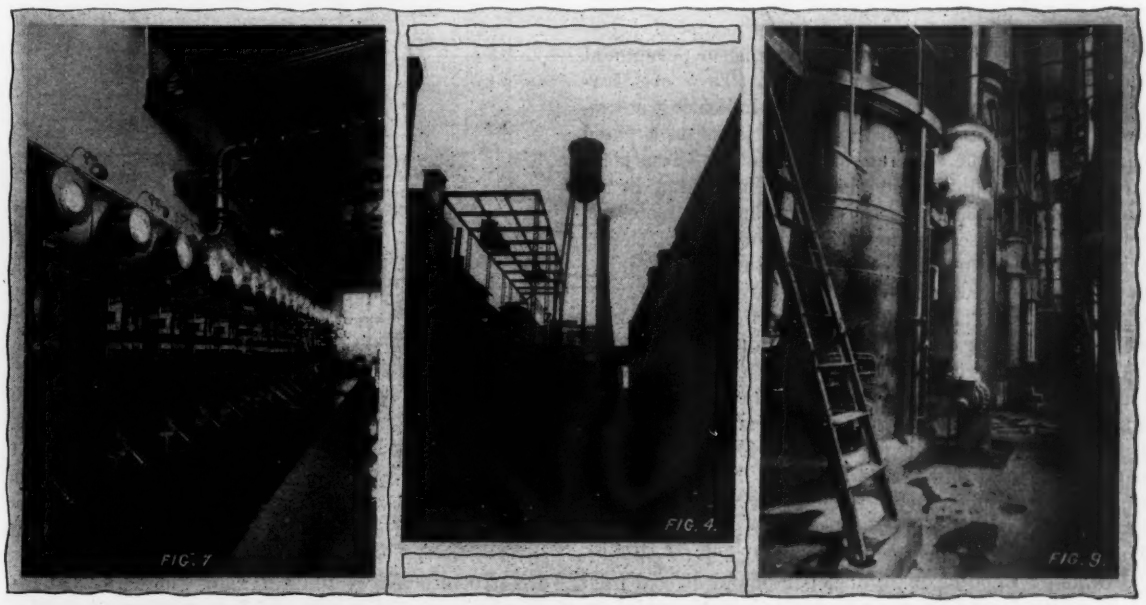


FIG. 4. MONORAIL COAL-HANDLING EQUIPMENT FIG. 7. MAIN SWITCHBOARD FIG. 9. VIEW OF GAS-PRODUCER ROOM

Automatic feed-water regulators fitted to each boiler maintain constant water level in the boilers under all conditions of load.

The feed-water heater is of the open type heated entirely by exhaust steam and has a nominal rating of 3500 hp. This heater, together with the economizers, maintains a feed-water temperature of about 300 deg. F. Simplex, direct-acting, center packed, plunger pumps, fitted with automatic regulating valves deliver the feed water into the boilers.

FIG. 6. VIEW SHOWING CORNER OF SPRAY POND

With this equipment, a normal evaporation of about 10 to 11 lb. of water per pound of coal is obtained.

INSTRUMENTS

IN ORDER to maintain the high degree of efficiency demanded of this power plant, it is essential that a close check be kept on all operations. To accomplish this, it is, of course, necessary that suitable instruments be provided. In addition to the usual steam and draft gages, each boiler is equipped with a steam-flow meter. These are of the recording type and are located, together with the steam and draft gage, on a panel attached to the boiler front. These meters therefore not only give the fireman an instantaneous means of determining the load on his boiler, but furnish a permanent record for the chief engineer as well. They are, furthermore, electrically connected to an indicating steam-flow meter in series with a number of jacks on a panel board located in the chief engineer's office. These jacks can be seen as indicated by the arrow marked A in the photograph, Fig. 3, where B is the steam-flow meter referred to. By inserting a plug into any one of the 12 jacks which bear numbers corresponding to the boilers they are connected to, the load on any boiler may be read instantly. The chief engineer is thus able to keep an accurate check on all the boilers at all times.

The panel board referred to above also contains the duplicate gas-flow meters which are in electrical communication with the flow meters on the gas producers. Recording and integrating gas-flow meters are provided to determine the amount of gas used by each department in the main factory. Each department is charged up with the quantity of gas, electricity and steam used, thus furnishing accurate data from which to compute the value of a pound of product per pound of coal used.

The CO_2 recorders are also located in the chief engineer's office. These may be seen to the left of the panel board in Fig. 3, one meter serving each battery of four boilers.

Centralizing duplicate instruments in the chief engineer's office in this manner not only eliminates a great amount of lost time otherwise incurred in making the rounds to the various instruments, but the operating force, knowing that the performance of the equipment under their care is under direct observation of the chief engineer at all times, will strive to make a better showing.

All records are carefully kept and inspected and serve as a basis for regulating operating procedure. This is, after all, the most important point of any instrument installation—the intelligent interpretation of their records. No installation of instruments, however elaborate, is worth one iota more than the second-hand value of the instruments themselves, if their records are not intelligently interpreted and the results consistently applied in daily operation.

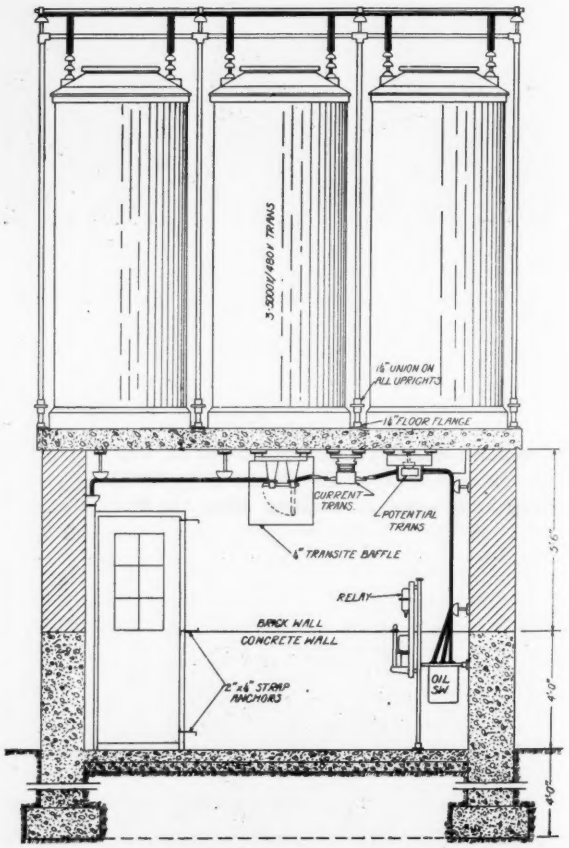


FIG. 8. SECTION THROUGH HIGH TENSION SWITCH ROOM, SHOWING POWER TRANSFORMERS ON ROOF

COAL AND ASH-HANDLING EQUIPMENT

A MONORAIL coal-handling system is provided. Coal is removed directly from the cars by a clamshell bucket and is then conveyed by the electrically operated monorail car, shown in Fig. 4, to the boiler or gas-producer room. In the boiler room, the grab bucket discharges directly into a travelling crusher which runs above the parabolic coal bunkers. After passing through this crusher, the coal is uniformly distributed along the

length of the bunkers. The latter are constructed of concrete and have a nominal capacity of 450 tons.

To insure against unforeseen conditions, a reserve coal pile of approximately 600 tons is maintained, the handling of which is effected by an auto crane.

Ashes are removed from the boiler room by a steam jet ash conveyor system, which discharges into an ash bin near the boiler house. Two branches are provided, one branch running directly in front of each line of boilers. This equipment has given excellent satisfaction.

Engine Room

The total rated electric generating capacity of the engine-room equipment is about 2800 kw., but under average conditions of load 3500 kw. are carried. The equipment consists of five units enumerated as follows:

One cross-compound Corliss engine 20 by 32 by 36, 120 r.p.m., direct-connected to a 400-kw., 480-v. a.c. generator.

One simple Corliss engine 28 by 36 in., direct-connected to a 400-kw., 480-v. a.c. generator. (Under ordinary conditions, these two engines exhaust into a 400-kw. low-pressure turbo generator.)

One cross-compound engine 22 by 44 by 48, 90 r.p.m., direct-connected to a 750-kw., 480-v. a.c. generator. This unit normally exhausts into a 940-kv.a., 480-v. a.c., 3600-r.p.m., low-pressure turbo generator. If desired, however, the above engine may be operated condensing, by transferring the exhaust into a barometric condenser. The two low-pressure turbo generators operate on a normal steam pressure of 16.4 lb. absolute. They are equipped with high vacuum jet condensers served by motor-driven circulating pumps.

Spray Pond

Water for circulating purposes is drawn from a spray pond 168 ft. long by 102 ft. wide, these being inside measurements. The pond has an average depth of about 3 ft. and has a normal reservoir capacity of 870,000 gal. It is constructed entirely of reinforced concrete, is fitted with 150 spray nozzles arranged in groups of five nozzles each, 10 groups in a row. With this arrangement, a turnover capacity of 6000 gal. per min. is obtained.

Two 3000-gal.-per-min. centrifugal pumps, each driven by a 30-hp. electric motor at 860 r.p.m. located in a pump house adjacent to the cooling pond, pump the water from the power plant into the pond. Suction is obtained through a 20-in. welded suction line running to the condensing equipment in the basement of the engine room.

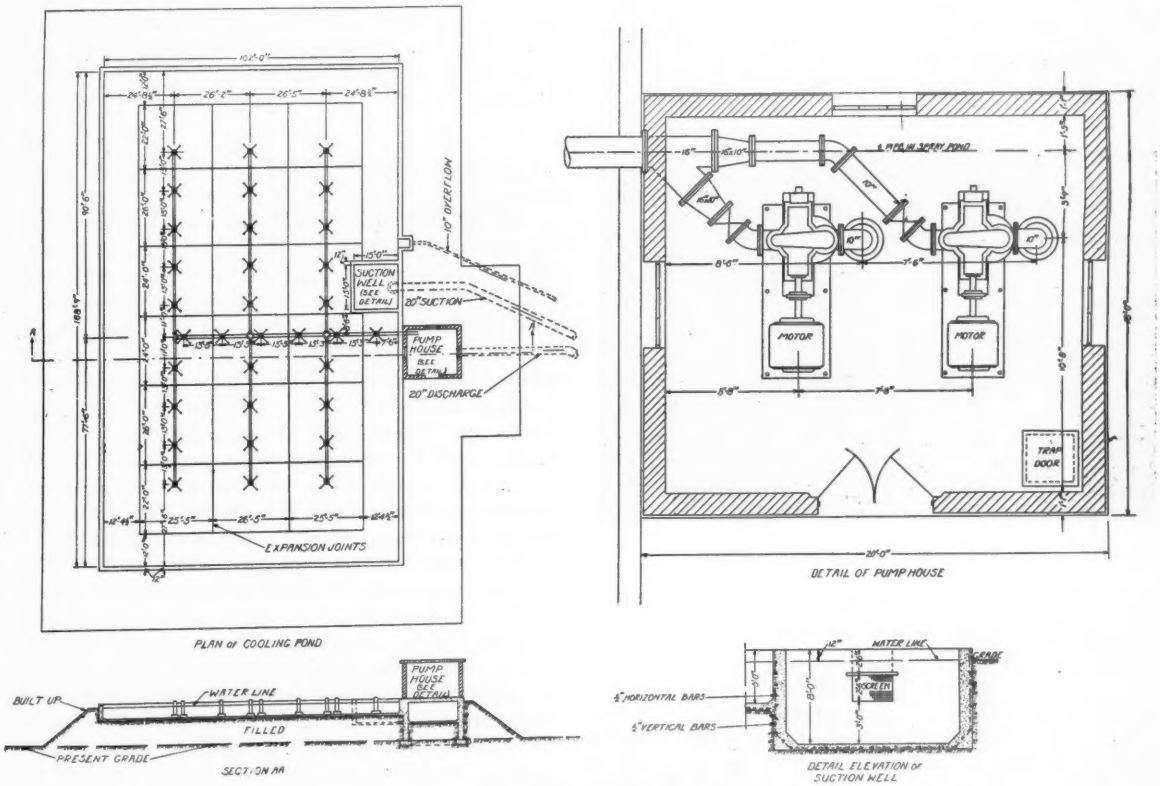


FIG. 10. DETAILS OF SPRAY POND AND PUMP HOUSE

Besides the large centrifugal pumps, the pump house contains a small vacuum pump used to prime the large centrifugals.

All water used at the plant, including that used for boiler feed, condensing and factory purposes is pumped from five artesian wells, each 104 ft. deep, by three steam-driven deep-well pumps. These pumps are located in the pump room adjacent to the fan room as shown in Fig. 2, and have a capacity of 500 gal. per min., which gives a total of 2,160,000 gal. per 24 hr.

A 75,000-gal. steel water tower 150 ft. high is provided for storage purposes. This tank furthermore gen-

erates the required head for forcing the water through the system. Water from the deep-well pumps discharges directly into the factory system and all water not used flows into the storage tank. With this arrangement, the pumps work against the head produced by the water tower at all times.

Water used as boiler feed is treated by a chemical process in the feed-water heater to precipitate the scale forming impurities present.

Electrical Features

Control and distribution of electrical energy is effected by a 21-panel switchboard, 40 ft. 6 in. in length, constructed of marine finished black slate and supported by an angle-iron framework. This is shown in Fig. 7. Beginning at the left, the panels are arranged as follows: Ten feeder panels, one synchronous condenser panel, one Public Service Co. panel, one generator totalizing panel, three exciter panels, and six generator panels, the latter group allowing provision for one future unit. The volt-meter, power-factor indicator,

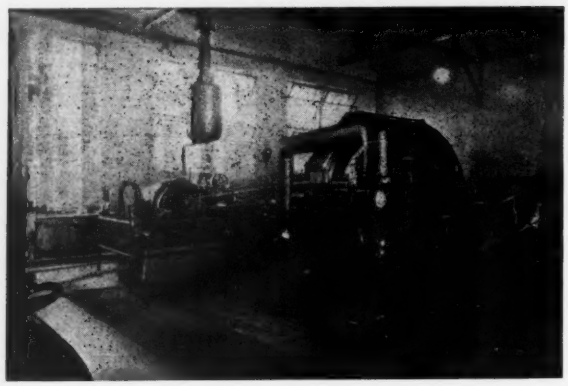


FIG. 11. CORNER OF ENGINE ROOM

synchronoscope, and frequency meter are arranged on swinging bracket supports at the right-hand end of the switchboard.

Two sets of busses are provided, one for the station generators and the other for the public service company lines. By means of triple-pole, double-throw transfer switches, located on each feeder panel, the load may be transferred from the station bus to the public service company bus or vice versa. The transfer switches are electrically interlocked with the oil circuit breakers on each panel so that it is impossible to open or close the transfer switch with the circuit breaker in the "On" position. Auxiliary contacts on the transfer switches trip the oil circuit breakers an instant before the circuit through the transfer switch can be broken.

All current generated is three-phase a.c. and is used throughout the factory at a pressure of 480 v. Excitation for the generators is provided by motor-driven exciters supplying current at 120 v. to a common exciter bus. Since the electrical load is made up largely of induction motors, a 900-kv.a., 60-cycle synchronous condenser is provided to offset the decrease in power factor due to the inductive load. This machine gives excellent satisfaction and no difficulty is experienced in maintaining a power factor of 90 per cent.

Current from the local public service company is transmitted at 5000 v. Three single-phase 5000 v./480 v. 60-cycle transformers located on the roof of the high tension switchhouse effect the necessary reduction in voltage for use in the plant. A section through the high tension switchhouse is shown in Fig. 8, which shows the high tension oil circuit breaker on the instrument transformers located in the switchhouse and the power transformers on the roof.

Gas Producers

Gas-producing equipment consists of seven 300-hp. and three 150-hp. gas producers, making a total of 2550 hp. Approximately 30 tons of anthracite pea coal per day is used, which furnishes some 3,300,000 cu. ft. of gas. All gas is used as it is generated, no reservoir capacity being provided. A gas pressure of 1 or 1¼ in. of mercury is maintained on the system by three steam-driven blowers, two of 10 ft. capacity and the other of 17 ft. capacity. Each producer is equipped with a flow meter which is electrically connected to the meters in the chief engineer's office as previously described.

Largest System of Automatic Substations Installed at Kansas City

THE LARGEST system of automatic stations in the world will soon be put in operation in Kansas City, Mo., by the Kansas City Light and Power Co. The entire Edison system of the city is to be controlled from a series of five automatic stations, each containing two synchronous converters, operating independently.

These five substations will all be fed from a central steam generating plant, through a network of radial feeders. The capacity of the generating station at present is 60,000 kw., but the ultimate capacity is expected to be more than 150,000 kw. The Edison system will have an approximate capacity of 15,000 kw.

The supply will enter each station at 13,200 v., 60 cycles, three phase and will be converted to direct current by two machines in each station. Eight of these are rated 250 v., 6000 amp., the other two being rated 250 v., 9000 amp. Each machine will be equipped with an automatic switching equipment so that, in case the line normally feeding it fails for any cause, power is immediately fed to it from another line. As soon as normal conditions are restored on the regular feeder, the machine is automatically switched back by this equipment.

The fact that a city of the size and importance of Kansas City has decided to use automatic station control, would seem to indicate that this type of station has made a permanent place for itself by its superior operating and economic features. Its development from the first remotely controlled stations which were installed in Detroit 10 yr. ago, to an installation this size has been as rapid as any in the history of the electrical industry.

Semper Perennial, Eh, Pat?

Book agent: "My man, let me sell you my book, 'How to Reduce Fuel Expenses.' It may mean a promotion for you."

Pat (fireman): "Sure, any dom fool knows thot fewel kin be saved by puttin' out the fire, but thot don't go here."

Efficient Operation of Oil Burning Steam Plants*

METHOD OF ESTABLISHING STANDARDS OF EFFICIENCY AT VARIOUS LOADS. BY C. H. DELANY

DURING the past 10 yr. there has been a remarkable increase in the efficiency of steam plants, both oil burning and coal burning. Ten yr. ago there were many plants operating reciprocating engines, in which the maximum economy obtained was not over 150 kw.-hr. per bbl. of oil.

With the high-pressure steam turbine plants of the present day, a record of 330 kw.-hr. per bbl. has been made. This increase in efficiency has been brought about by introducing more efficient machinery and increasing the range of steam pressure in the prime mover. The introduction of the steam turbine to replace the reciprocating engine effected a remarkable saving in the quantity of fuel required. Moreover, the steam turbine caused a saving in operation due to the fact that its operation does not depend on the personal element in the plant.

In the old reciprocating engines there were many adjustments to be made by the engineer in charge, and the economy obtained depended very largely on the skill of the operating engineer and the care with which he made the various adjustments. With the steam turbine, however, there is nothing that the operator can do to improve the efficiency after the machine is once installed and placed in good operating condition. While this is true as regards the prime mover, it is not true in regard to many other features of the power plant.

In the boiler room particularly there are many points where the operating engineer can effect a saving if he carefully studies the situation and pays attention to the small details of operation. In condensers and vacuum pumps, also, a great saving can be made if proper attention is paid to maintaining a high vacuum. There is still, therefore, a large field for the operating engineer in improving the economical operation of the plant, and the question of operating efficiency is, therefore, one worthy of very careful study.

COMPARISON OF DAILY EFFICIENCIES

MANY TESTS have been published showing very high efficiency of boilers where fired with fuel oil, efficiencies as high as 80 and 82 per cent being not uncommon in test reports. It is rare, however, that any such high efficiencies are obtained in the regular operation of power plants. In order to maintain high efficiency in regular operation of a plant, the first requisite is some means of comparing one day's operation with another. In oil burning electric power plants, it is customary to report the economical operation of the plant in terms of kilowatt-hours generated per barrel of oil. This is an excellent method of comparing one day's operation with another, provided there is steady load on the plant, and conditions remain the same from day to day. With a variable load, however, such as occurs in an ordinary central station plant, it is always found that the economy is much better at periods of heavy load, and poorer at periods of light load. Thus it is possible with a fairly heavy load on the plant to secure from 220 to 230 kw.-hr. per bbl. of oil without difficulty, whereas with the steam plant operating at a light load, it may be difficult to secure more than 150 kw.-hr. per bbl. of oil.

When the good results are obtained with the heavy load, the operating men pat themselves on the back and consider that they are doing fine, because results are better than the average. On the days of light load when the results are poor, they do not worry but say, "What's the use, you can't expect any results with such a light load." Thus in neither case is there any incentive to improve the economical operation of the station. Another reason for more or less lax methods, so far as efficiency is concerned, is the fact that efficiency must always be secondary to continuity of service. The men at the plant know that any interruption to service will be a matter of close investigation on the part of the management, and they devote all of their energies to maintaining the plant in operation and keeping the lights burning.

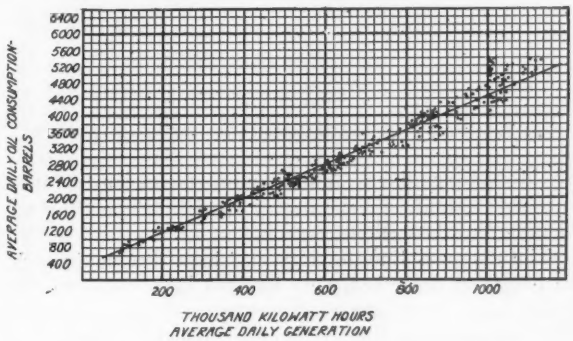


FIG. 1. PLANT CHARACTERISTIC DIAGRAM

For instance: If a fireman in endeavoring carefully to adjust the air supply in his boilers neglects to keep up the steam pressure, with the result that the turbine slows down and some of the load has to be dumped, he is sure to be called on for an explanation. If, on the other hand, he keeps up the steam pressure but neglects to regulate the air in the proper proportion, there usually will be no complaint; and the boilers may be allowed to operate in this inefficient manner for a considerable length of time. I am far from disputing the fact that continuity of service is a matter of prime importance, but I do wish to point out that efficiency is a close second. The problem before us, therefore, is so to interest the men who are operating the plants in the matter of efficiency, that they will not neglect the various operating details that must have attention in order to secure good results.

PLANT CHARACTERISTICS

IN ORDER to improve these conditions and to interest the men in the problem of efficiency, it is essential to devise some means of comparing the performance of a plant from day to day. For this purpose, the diagram which I have called the Plant Characteristic Diagram has been plotted.

Figure 1 shows such a diagram for one of the stations. It consists merely in the plotting of the oil con-

* Paper read before the San Francisco Section of the American Society of Mechanical Engineers

sumption against the kilowatt hours generated. Each of the points in this diagram represents one full day's operation, and while the points as shown on the diagram are more or less scattered, it is apparent that they form a well defined line. It is thus possible to draw a straight line through the midst of these points in such a way that it will represent the average location of all the points on the diagram. There is nothing new in the use of a straight line diagram such as is presented. The line is similar to the Willans lines for steam engines where the total steam consumption of an engine plotted against the horsepower output is always found to be a straight line

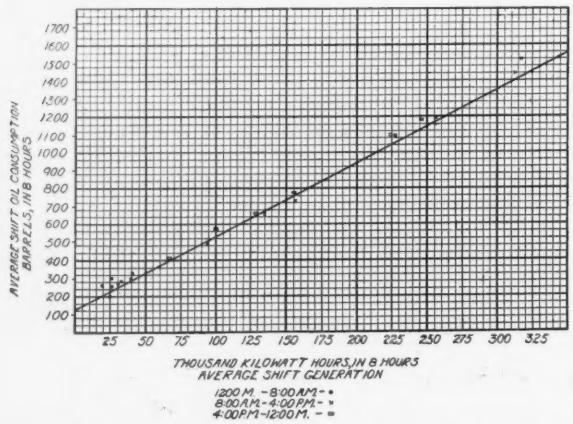


FIG. 2. PLANT CHARACTERISTIC TO COMPARE SHIFTS

for throttling engines. A similar line for steam turbines is either straight, or very nearly straight, depending on the design of the turbine.

The diagonal line, having once been drawn through the points as described, may be used as a standard for the guidance of the men in future operation of the plant. Thus each day the kilowatt-hours generated and the oil burned the day before, may be plotted on this diagram. If the point so plotted is found to fall below the diagonal line, it is evident that the results obtained are better than the standard. If the point falls above the line, too much oil has been used, and there is something wrong requiring a special investigation; and since the diagram takes in all loads from zero up to the full load on the plant, it is evident that it allows for the poor economy obtained at light loads. It is thus possible for the operating men to know immediately whether they are keeping up to the required standards of efficiency or running behind. They are, therefore, able to investigate causes of low efficiency immediately, while all matters entering into the plant operation are fresh in their minds.

In adopting the standard, it would be possible, instead of drawing a line through the average of the points, to draw a line through the best points, thus establishing a standard that would represent the best results obtainable from the plant. Again it would be possible to establish a standard by drawing a theoretical line below all of the points, this line to be based on the steam consumption of the turbines and auxiliaries, as determined by tests, a boiler efficiency of say 80 per cent and the best possible vacuum; in other words, a line representing ideal conditions.

In adopting the average line as the standard, it is felt that the men will have greater confidence in the method than if a theoretical line had been adopted. The average line is really a standard that has been established by the men themselves. It is not an arbitrary ideal impossible to attain, but as it represents the average already attained, it should be as easy to improve on the results represented by the line as to fall below them.

If the men are successful in improving on the standard each day, it is obvious that the average for the present year will represent better efficiency than the average for the previous year. With all of the points falling below the line on the diagram, another line drawn through the average of these new points would also fall below the original line.

A diagram with the same diagonal line as determined by Fig. 1, but with the points omitted, may be used at the stations each day to plot the results of the day before.

Comparing Shifts

FIGURE 2 shows a similar diagram, but with the scale altered so as to show the kilowatt-hours generated, and the oil burned during a period of 8 hr., instead of 24 hr. This diagram may be used by the different shifts in the station so that each shift can check up his own performance and compare it with the performance of the other shifts. A large diagram of this form is posted on the wall of the fire room, and different colored pins to represent the different shifts are inserted each day so that the diagram shows at all times which shift is running above the line and which shift is running below the line. This system has a far-reaching effect in awakening interest in the men, and leads to rivalry and competition so that

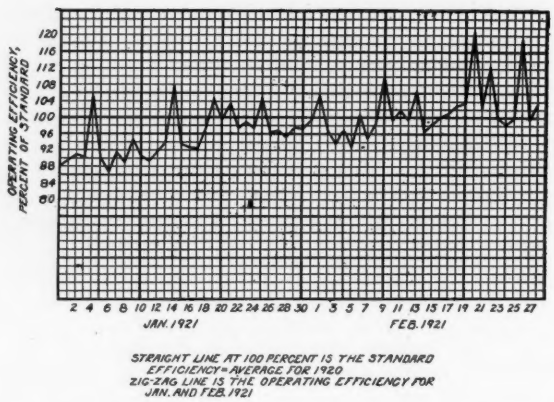

OPERATING EFFICIENCY, PERCENT OF STANDARD
120
116
112
108
104
100
96
92
88
84
80
2 4 6 8 10 12 14 16 18 20 22 24 25 28 30 1 3 5 7 9 11 13 15 17 19 21 23 25 27
JAN. 1921
FEB. 1921
STRAIGHT LINE AT 100 PERCENT IS THE STANDARD EFFICIENCY = AVERAGE FOR 1920
ZIG-ZAG LINE IS THE OPERATING EFFICIENCY FOR JAN. AND FEB. 1921

FIG. 3. DAILY VARIATION IN OPERATING EFFICIENCY

the men are extremely anxious to improve the efficiency, and the laxity which previously existed in regard to efficiency is disappearing. As the diagram allows for variations in load, it is possible to compare the day shift when the load is heavy with the early morning shift when there is very little load on the plant, thus making a fair comparison which was never possible with the old method of merely figuring the kilowatt-hours per barrel of oil.

There is one objection to the diagram, namely: that it does not indicate the order in which the records are plotted, and therefore does not show whether the results are improving as time goes on. In order to overcome this objection, and also to enable the operation of different

plants to be compared with each other, the term "operating efficiency" has been introduced.

Operating efficiency as used in this connection means the per cent of standard attained for the day's run. "Operating efficiency" is entirely distinct from "boiler efficiency" or "turbine efficiency" or "thermal efficiency" or "Rankine cycle efficiency." All of these entered into the operation of the plant in determining the standard.

Operating efficiency is merely a comparison of the results actually obtained with the standard. The method of determining operating efficiency can best be shown by an example: During one 8-hr. shift there were generated 313,000 kw.-hr. and 1440 bbl. of oil were burned, representing an economy of 217 kw.-hr. per bbl. From the diagram it is found that for a load of 313,000 kw.-hr. with standard efficiency, there would be burned only 1400 bbl. of oil, which would be equivalent to 224 kw.-hr. per bbl. The operating efficiency is therefore 217 divided by 224 equals 97 per cent.

During another 8-hr. shift, where there were only 25,000 kw.-hr. generated, the oil burned was 200 bbl., equivalent to 125 kw.-hr. per bbl. From the diagram it is found that for 25,000 kw.-hr. with standard efficiency the oil burned would be 220 bbl., equivalent to 114 kw.-hr. per bbl. The operating efficiency is therefore 125 divided by 114 equals 110 per cent. It is thus seen that although in the second case there were only 125 kw.-hr. per bbl. obtained, as against 217 in the first case, the operating efficiency was actually higher in the second case than in the first.

It is evident from the foregoing that if an operating efficiency of 100 per cent is obtained, it means that the economy of the plant is the same as the average of last year, since last year's records were used to establish the standard. If more than 100 per cent operating efficiency is obtained, the results are better than last year, and if less than 100 per cent is obtained, they are worse. It is obvious that this method of determining operating efficiency makes allowance for inefficient machinery, and it is just as easy to obtain 100 per cent operating efficiency in a plant having old-fashioned turbines of poor design as in a plant having the most up-to-date machines, for the standard is based on the actual records of the plant in question.

Figure 3 shows the operating efficiency of one of the plants plotted for each day during the months of January and February. In this diagram, the horizontal line at 100 per cent represents the standard efficiency, and the zigzag line represents the actual operating efficiency obtained each day. The records show a gradual improvement in the operating efficiency during the period, which is a direct result of the attention to small details brought about by this method of checking up efficiency.

In addition to the use of the diagram for setting standards and creating interest among the men, a system of weekly and monthly reports and bulletins has been adopted. The weekly report, which is made out by the efficiency man at each station, gives the operating efficiency for each day and the average for the week, and in addition a brief statement of some of the more important instrument readings such as flue gas analysis, vacuum, feed water temperature and steam consumption of turbines at different loads.

The monthly report which is made out at the office and sent to each station includes a diagram of operating efficiency similar to Fig. 3 for all stations plotted on one sheet, together with a brief statement of comparative results obtained and suggestions for improved methods. A liberal use is made in the stations of flow meters and other instruments that serve as a guide to the firemen in the proper regulation of their fires.

The General Formula

Since the diagonal line in the plant characteristic diagram is usually a straight line, it can of course be represented by a simple equation.

$$y = a + bx$$

where y = oil consumption in a given period in barrels or pounds, x = kw.-hr. generated in the same period, and a and b are constants.

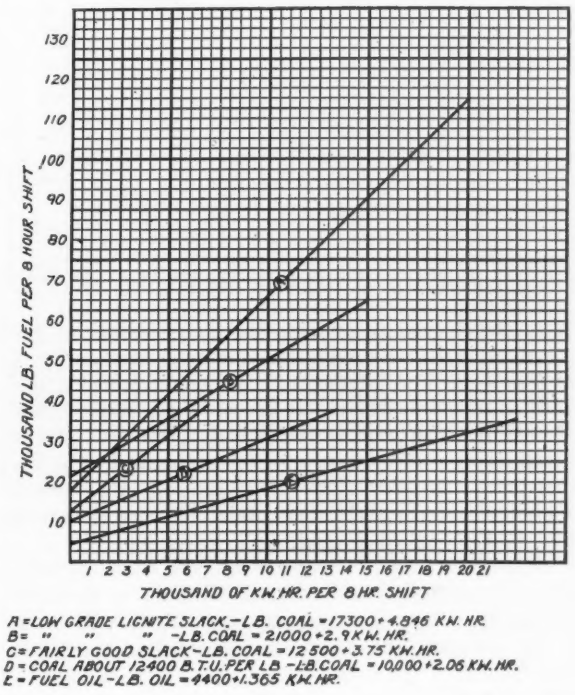

THOUSAND LB. FUEL PER 8 HOUR SHIFT
130
120
110
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
THOUSAND OF KW. HR. PER 8 HR. SHIFT
A = LOW GRADE LIGNITE SLACK.—LB. COAL = 17300 + 4.846 KW. HR.
B = " " " —LB. COAL = 21000 + 2.9 KW. HR.
C = FAIRLY GOOD SLACK—LB. COAL = 12 500 + 3.75 KW. HR.
D = COAL ABOUT 12400 B.T.U. PER LB —LB. COAL = 10,000 + 2.06 KW. HR.
E = FUEL OIL—LB. OIL = 4400 + 1.365 KW. HR.

FIG. 4. PLANT CHARACTERISTICS WITH VARIOUS KINDS OF FUEL

Evidently the constant a is equal to y when x = 0, or in other words a represents the quantity of oil burned for zero load, that is the amount required to keep up steam on the boilers, keep the turbine running up to speed, operate the vacuum pumps, circulating pumps and other auxiliaries, and keep the entire plant in readiness to take on load at a moment's notice. Obviously the constant a will be larger if two turbines with their auxiliaries are kept in operation than only one, so that its value depends on the amount of load the plant is expected to take on.

Where a plant is operated as a standby to a hydroelectric system and is kept in readiness instantly to pick up its full load in case of trouble, the constant a will have a higher value than where it is possible gradually to shut down the turbines one after the other as the load falls. The constant b evidently represents the additional

amount of oil burned in proportion to the load carried on the plant. It determines the slope of the line in the diagram, and is large for uneconomical turbines or engines and small for the most efficient types. The equation of the line in Fig. 2 in terms of barrels of oil and kilowatt-hours for an 8-hr. shift is

$$y = 120 + 0.0041\ x$$

Robert H. Parsons gives a few equations taken from records of actual coal burning power stations. From these equations, the lines shown in Fig. 4 have been drawn, and in addition a line made up from actual records of a 5000 kw. oil burning turbo station. The

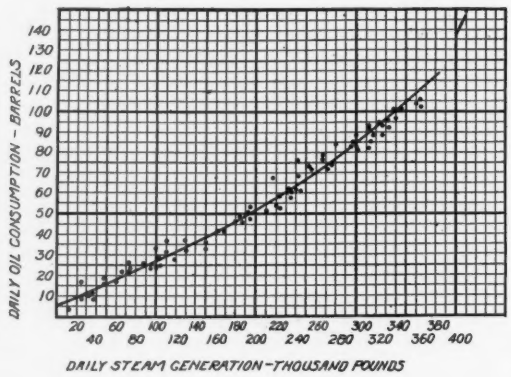


FIG. 5. OIL-STEAM CHARACTERISTIC FOR SMALL PLANT

superiority of oil to coal, pound for pound, is at once apparent both for standby, as shown by the low point at which the line intersects the ordinate for zero load, and for regular operation as shown by the slighter slope of the line. The great variation in different coal burning plants is also of interest, and is explained by the fact that there is as much difference in heating value between a high-grade coal and a low-grade, as there is between fuel oil and coal in general.

The characteristic diagram may be used for many other purposes besides to overall efficiency of the plant. By plotting the steam generated against the oil burned in one diagram, and the steam consumption against the kilowatt-hours generated in another, it is possible to study the boiler room and engine room operations separately, and thus quickly locate the cause of low efficiency. By setting separate standards for the boiler room crew and the engine room crew, responsibility can be more definitely fixed, and the advantages of the system of operation greatly enhanced.

Figure 5 shows the steam generated plotted against the oil burned in a small steam heating station. In this case the plant characteristic is a well-defined curve rather than a straight line. Figure 6 shows a similar diagram for a somewhat larger steam heating station, and it will be noted that in this case the line is more nearly straight. Since boiler efficiency usually decreases quite rapidly as the capacity increases above the boiler's rating, a single boiler will naturally have a curved characteristic. In a plant containing a large number of boilers, however, the boiler room characteristic will be approximately straight until the load exceeds the economical capacity of all the boilers in the plant, after which it will begin to curve upward. A curved line, based on previous performance, is just as satisfactory as a straight line for setting standards and calculating operating efficiency in the manner described.

Figure 7 shows the power used by electric auxiliaries in a station, plotted against the total generation, and is of interest in showing that the points do form well defined straight lines, and that the same methods may be used for standardizing these items, as for fuel consumption and steam consumption.

To sum up—the essentials for securing the best efficiency in power plant operation are:

1. A fair standard by which the daily performance can be measured and compared with previous results, at the same time giving the operating men a definite goal to work to.

2. Means of comparing results obtained by different groups of men, such as different shifts of one plant or the crews of different plants, and the posting of this comparison so that the men can see the results of their efforts.

3. A system of reports that keeps up the interest of the men, combined with suggestions and advice that show where losses occur and how they may be avoided.

If the operating men are kept interested, see the results of their work, have a definite standard to reach, they will do their best. As interest flags some sort of bonus or prize for the crew showing the best operating efficiency will stimulate them to greater effort, and by guiding this effort by means of thoughtful analysis of the technical features of the power plant, maximum efficiency may be obtained.

Discussion

E. A. Rogers: There are many interesting possibilities in this scheme, one of which we ran up against at

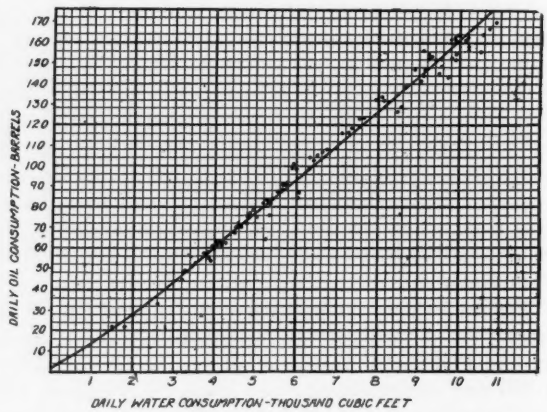


FIG. 6. OIL-FEEDWATER CHARACTERISTIC FOR STEAM HEATING PLANT

Ajo, Arizona, and that was that in springing something of this character on operators, you are apt to start something. We lost one or two of our best firemen before we got down to a point where everybody was satisfied with a plant run along that line. That came about principally through working one shift against another. It got to the point where the fellows came pretty near packing guns to prove their results. At the time we were making an average of probably 310 to 315 kw.-hr. per bbl. net, and it was nothing uncommon to have some fellow show up with a shift running up in the neighborhood of 350.

They would resort to every method they could think of to get the oil reports away from the other fellows, to juggle their kilowatts a little bit to make their shift come out the best. That, however, is checked up by the efficiency man on the daily run so that does not influence your daily record; but in comparing one shift with another, it is quite an interesting proposition to work out something that will be fair to all. We finally settled on the system of having the man going off watch check up with the man coming on watch on all the readings that were taken and that seemed to be the only fair way we could get a fair check on results.

In regard to increasing efficiency from year to year, I think that probably, under this system, not later than the second or the third year, if you use previous year's records as a comparison, you are going to reach a point where no improvement will be made, unless some such system as Mr. Delany suggested as a bonus is adopted. Probably the second year they would attain the best that they could attain without some such form of participation in the savings. To my mind the real solution of the problem, as far as firing is concerned, is the automatic regulation of the fires.

I might give, in connection with that plant, the figures for one month which I have in mind, the month of December, 1919, when we had a comparatively light load. The average load for the month on the boilers—this is speaking of the boilers alone—was 93 per cent of their load capacity. For that month, the actual operating data showed that the boiler and economizer efficiency was 84½ per cent. The gross boiler efficiency alone was 80 per cent and the net, deducting the atomization which was 1 per cent, made 79 per cent net for the monthly operating efficiency of those boilers under automatic control. The saving in atomizing steam, to my mind, is a very important item there. I checked up pretty carefully that item and found that the best they could possibly do was approximately 2 per cent under hand control, and we got 1 per cent, if the meter was absolutely right, at times slightly under 1 per cent, with the automatic control.

I think that it is very important to segregate the boiler and turbine room efficiency. If the feed condensing water temperature is fairly constant, the day to day changes in the turbine room are relatively unimportant, but the boiler room is the thing that should be watched, and I believe most of the efficiency work has been done in that direction.

THOMAS STILLMAN: On the east coast an oil-burning plant is a rarity, out here there is nothing else. Up to a year ago, I do not think any of the large eastern plants burned oil at all. All the plants were coal fired. When it comes to the question of automatic regulation and things like that, there was practically nothing on the east coast at all that we could turn to and we had to come out to the west coast to see such auxiliary apparatus. When they changed some of these coal burning plants to oil burning, they had to take a plant which was operating normally at 200 per cent rating or higher. The under-feed coal stokers are usually operating at those rates. That raised a condition, when it came to oil, that was not duplicated on this coast, and raised a new issue which could not be met in the usual way that it was met out here with steam atomizers. That led to a long series of experiments covering six months, during which a new mechanical burner was developed, primarily for stationary work, and although that was only put on the market a little over a year ago, we have made a number of installations and so far every one has given entire satisfaction. We have obtained records well over 300 per cent. At one electric company's plant they obtained a 300 per cent report and 80 per cent efficiency, getting practically a straight line efficiency curve over the entire desired range. This, of course, is rather an unusual condition, especially as compared with steam atomizers. Three hundred per cent ratings in steam atomizing plants is practically unknown. Of course, feed water troubles were expected, as in some cases in burning the oil the ratings secured were even higher than were the coal ratings, and the furnace temperatures cor-

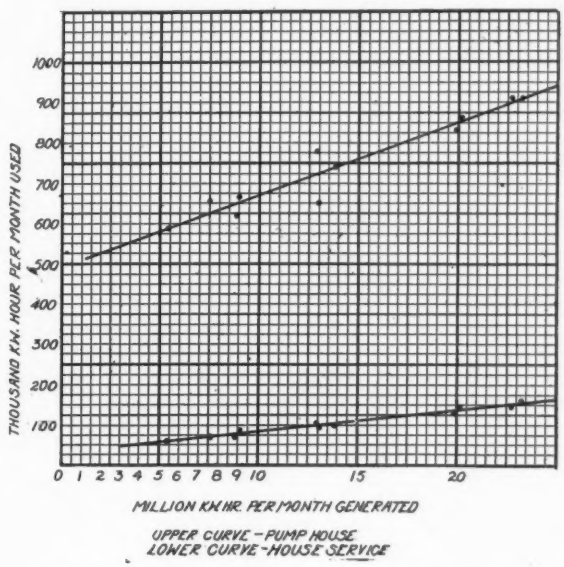


FIG. 7. OPERATING CHARACTERISTICS FOR ELECTRIC AUXILIARIES

responding, this, of course, being brought about by the better combustion conditions possible with the oil.

We can put a mechanical burner on a fairly low setting, that is, the burner fairly close to the tube, without danger of blow pipe action affecting the tube. With the mechanical burner, we can leave the bridge wall in place, with a solid floor underneath and very little necessity for changing the design. Thus it makes a simple and relatively cheap construction. With a 7-ft. furnace setting, we have obtained 272 per cent rating without injury to either the tubes or the furnace brickwork.

To obtain these high ratings, a forced draft is necessary. That is readily obtained by taking the air from the stoker blowers, puffing it into a double front and giving any rating desired, provided there is enough draft to take the gases through the tube bank and up the stack. To obtain normal ratings, that is, ratings from 150 to 200 per cent, we can obtain that with a single front design without the forced draft, combustion conditions being just as satisfactory at low ratings as at the high ratings. The only point is that more satisfactory efficiency results will be secured with the double front, due to the balanced draft condition we can obtain in the furnace when forced draft is used. Otherwise, there is no particular

need of the double front construction. At the present time, you are operating here at ratings around 150 per cent, with a fairly high normal load. That condition, as time goes on, will in all probability change. The cost of new boilers will become a more important item as more power is required, and instead of buying more boilers there will be a tendency to increase the rating of the present equipment.

Corrosion of Boiler Supporting Columns

SULPHUR IN ASH AND SOOT EATS AWAY MAIN COLUMNS SUPPORTING BOILERS. BY GEORGE C. STIERHOFF

A VITAL enemy of iron or steel is sulphuric acid. If the sulphur in the coal could be eliminated it would save us quite a few of our boiler troubles. Engineers are aware of this undesirable element getting into the tubes or drums of their boilers, and much attention is given to eliminating it from their feed water by use of the various compounds and water treatment devices. Engineers also realize that when it comes to the time for them to clean and prepare their boilers for an internal inspection, the brickwork must be removed from around the blowdown pipe; if the engineer in charge does not issue these orders to the one cleaning the boiler, the inspector will remove them himself.

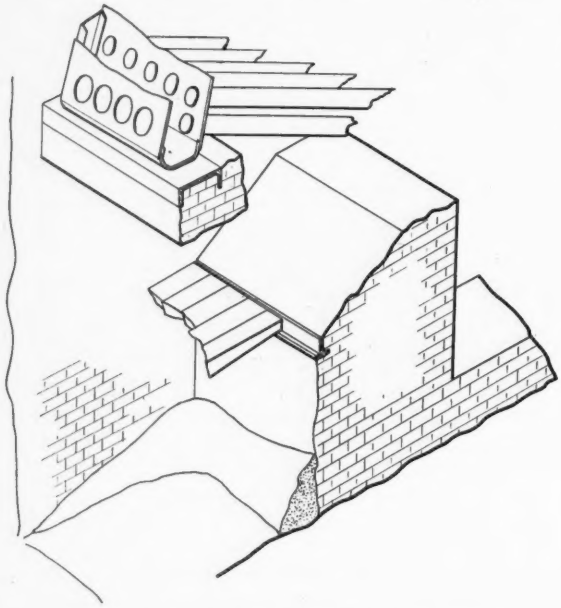


FIG. 1. TYPICAL ASHPIT OF WATER-TUBE BOILER

The inspector realizes the great danger in allowing the soot and ash to bank around the boiler blowdown pipes. This soot contains a large amount of sulphur, and when it becomes damp or wet soaks through the brick work whereby the sulphur and the oxygen in the water set up a chemical action. This chemical action causes pitting or corrosion which will in time eat through the metal if allowed to remain, and when the boiler is blown down may crack or explode, thereby blowing the fire into the fire room, possibly injuring several persons, and such accidents are frequent. Lists of accidents are published periodically by insurance companies or by the department of labor at Washington. Boiler blow pipes usually must be replaced about every 5 yr., and accidents resulting from them usually cause considerable delay and expense.

How many engineers ever examine the foundations of their boilers, or the columns which support the entire mass of weight? The owner would certainly object if you were to tell him that it would be necessary to remove a part of the brick work at the base of the sidewalls of his boilers especially where the boilers are in batteries.

Here is a vital consideration that should be called to the attention of all boiler inspectors and engineers, and it is something that we cannot lay too much stress upon. I frequently find in my visits to power plants trouble resulting from corrosion at the foundation of main boiler supporting columns. Upon one of my visits, I found that these columns that had been supporting a 1000-hp. water tube boiler had become so corroded at the base that it was amazing how it had stood. The brick work or sidewalls evidently had been supporting the boiler against collapsing. After this discovery, the brick work was removed from around all of the boilers in three large power plants operated by the company and five similar boilers were found in like condition, which had to be replaced at great expense and inconvenience.

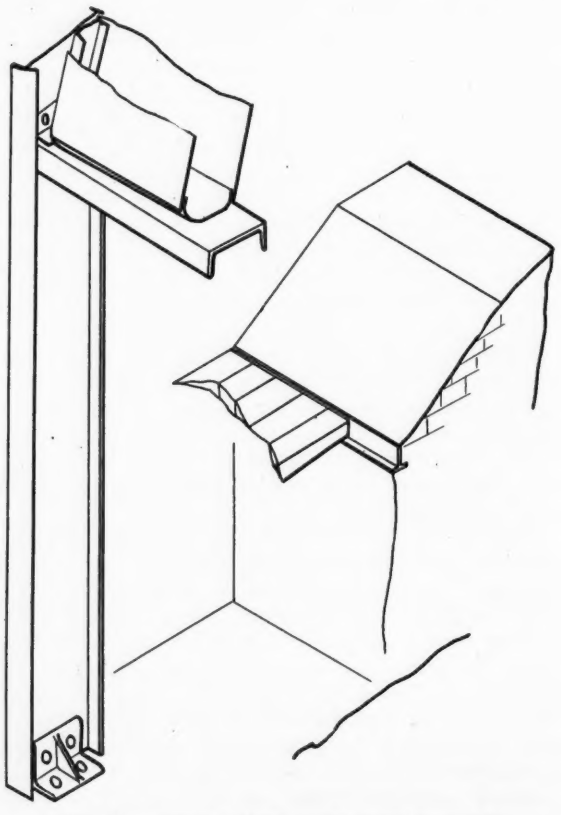


FIG. 2. ASHPIT WITH BRICKWORK REMOVED

Upon examination of these columns we found that the ash and soot that had piled up along the sidewalls, and the water resulting from the quenching of the hot coals penetrated the brick work and the sulphur in the refuse with the oxygen in the water quickly consumed the steel, causing this serious damage.

Figure 1 shows a typical ashpit of a water-tube boiler with the steel column hidden. Engineers seldom if ever stop to think that anything would ever happen to them as, to the eye, they look pretty well protected. But, engineers, you must realize that this protection is

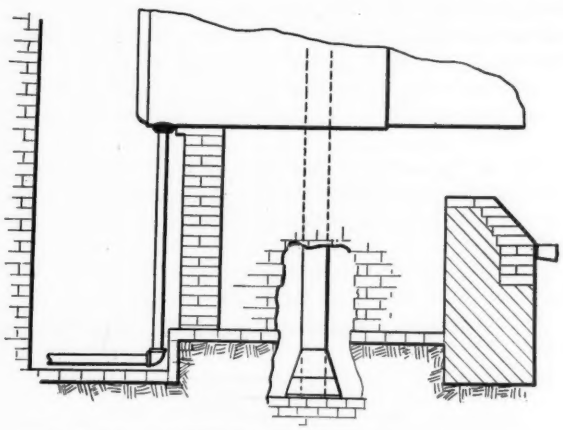


FIG. 3. LOCATION OF COLUMNS SUPPORTING RETURN TUBULAR BOILER

only a porous fireproof brick which will absorb moisture readily. This moisture must pass through the ash or soot. Coal from some mines will run about 4½ per cent sulphur, and when referred to sulphur in the ash this figure is considerably higher. So it may be well understood that this moisture passing through the ash will absorb much of this sulphur, and if allowed to remain on the steel will cause rapid corrosion.

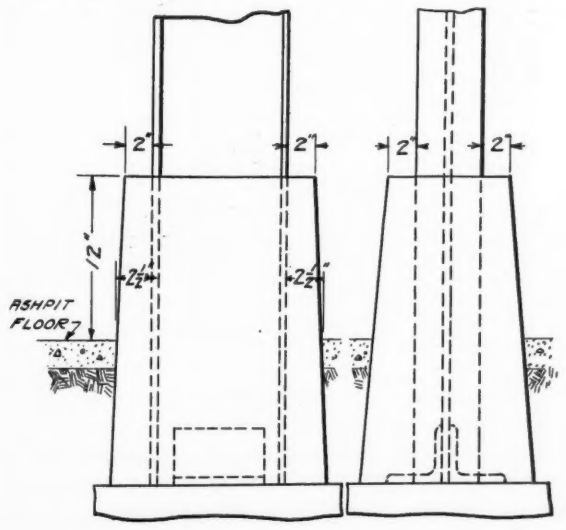


FIG. 4. CONCRETE CASING TO PROTECT BASE OF COLUMN

Figure 2 shows the same ash pit of a water-tube boiler with the brick work removed. In this view, see how the main columns are located at the side of the ash pit. In Fig. 3 is shown how the column is located on a horizontal return tubular boiler with the brick work removed from around the base. This brick work should be removed for a periodic examination.

You can prevent this corrosion by building a foundation of a good cement around the base which will extend about one foot above the ash pit floor the proportions for which are shown in Fig. 4.

In Fig. 5 A is shown an enlarged view of the columns that had to be replaced in the foresaid plant, and 5B shows how they had been corroded away when discovered; the metal had been so eaten away that there was practically no support whatsoever. I feel confident that if engineers would examine their boiler foundations, not less than 25 per cent would find just such conditions.

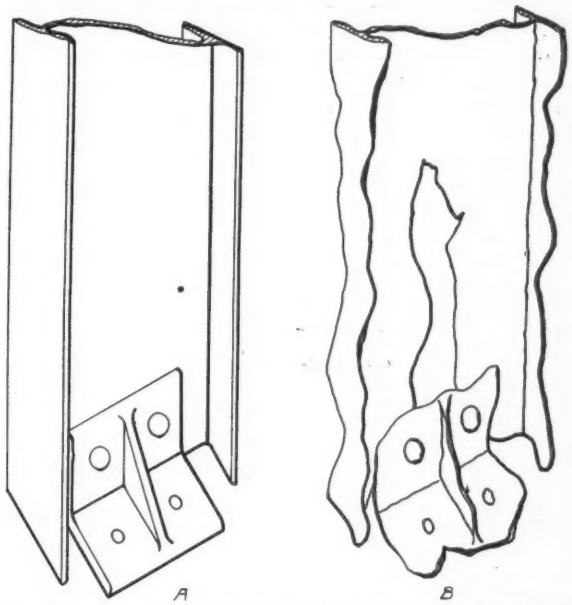


FIG. 5. FOOT OF COLUMN BEFORE AND AFTER CORROSION

The Intellectual Marathon

DURING THE late war, engineers, when examined, showed an excellent mental alertness. Of course, that is what everybody expected, nevertheless it is pleasing to the profession. Withal there is at times too much petty jealousy among the folks engaged in the various engineering professions.

It always has been and always will be the case that the mental alertness of some people is greater than that of others, regardless of whether they are engaged in professions or trades. Envy not the other fellow, but try to find out why he is so much more proficient than you are; in such an honest endeavor you will garner much that will be helpful to you to get nearer the "celebrity," or possibly it may be the means of having the crown placed upon your own head.

To win a race you must be one of the participants and not a wishing spectator seated upon a cushioned seat in the grandstand.

Withal, if we were all "celebrities," there would be no such animal.

Auxiliary Equipment of a Central Station Power Plant

Main and Auxiliary Busses Are so Connected as to Maintain a Proper Plant Heat Balance. By H. W. Smith*

IN THE DESIGN of a modern central station power plant, auxiliary equipment plays a most important part. Should these auxiliaries be driven electrically or by steam? The question resolves itself into one of maintaining a correct heat balance. If, for instance, the main generating units are operated condensing, the condensed exhaust will be comparatively cool and heat must be applied to raise its temperature before it is fed back into the boilers. Live steam may be used for this purpose, but such practice would be wasteful. The obvious method would be to provide exhaust steam. This steam may be obtained from steam-driven, noncondensing auxiliaries. If, however, all these units were steam driven there would, in all probability, be a superabundance of exhaust and the surplus would be wasted. The problem is to strike a balance. This will not, however, be a constant balance; for every variation in the load on the plant the balance will vary, and for this reason, there should be some method by means of which a portion of the auxiliary load may be transferred between the main generating and the auxiliary system. Let us assume a central station power plant with certain given equipment.

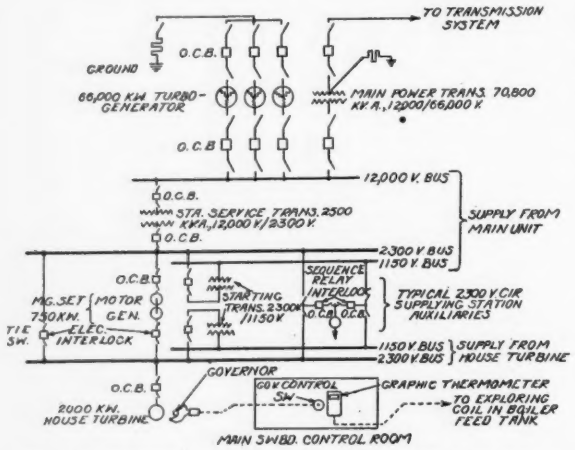


FIG. 1. CIRCUIT DIAGRAM OF AUXILIARIES AND HEAT BALANCE CONTROL

This installation for instance consists of one, three-element, cross-compound turbo generator unit, made up of one high-pressure and two low-pressure units of 23,600 kv.a. capacity each, making a total of 70,000 kv.a., three-phase, 60-cycle, 12,000 v. To supply steam for this unit there are installed seven cross-drum water-tube boilers having 20,876 sq. ft. of heating surface each. No economizers are used and two self-supporting steel stacks 325 ft. high and 21 ft. diameter provide the draft.

The auxiliaries will be partly steam and partly motor driven. The steam auxiliaries should comprise: (1) three boiler feed, four-stage, centrifugal pumps, each 1500 gal. per minute, driven by steam turbines; (2) three 250,000 cu. ft. per min. fans driven by 420 hp. geared turbines; (3) a house turbo-generator rated at 2000 kw., 2300 v., three-phase, 60-cycle; the turbine operates at boiler pressure and exhausts into a barometric condenser used as a feed-water heater.

The electrically driven auxiliaries will be supplied partly from the house turbo-generator and partly from the main bus. All motors above 75 hp. will be 2300 v., three-phase, 60-cycle, supplied either from the main bus through a 2500-kv.a. transformer bank, reducing the voltage from 12,000 to 2300 v., or from the house turbo-generator.

Motors below 75 hp. will be 440-v., and will be supplied from a 600-kv.a. transformer bank connected to the 2300-v. bus.

In laying out the auxiliary drives, reliability of operation, correct heat balance at varying loads, and first cost are considerations which must be given attention.

In this plant the arrangement of the feed-water heating equipment should be as follows:

The auxiliary live steam will be used to produce as much mechanical power as possible before its heat is used for other purposes. The amount of exhaust steam from the boiler feed pumps and draft fans will always be less than the minimum necessary, and the additional steam from the house turbine should be controlled at will by transferring load electrically between the generators of the house turbine and the main turbine. Part of the exhaust steam from the boiler feed pumps and forced draft fans will be first used in the evaporator for evaporating the make-up water. The main conden-

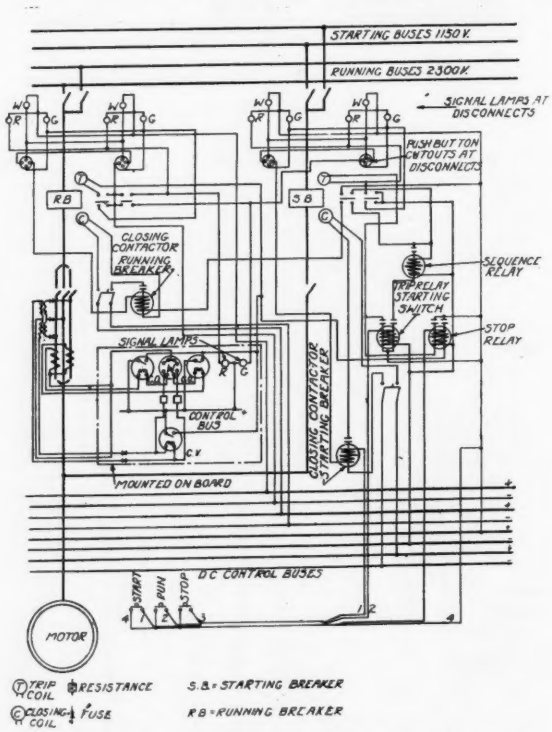


FIG. 2. TYPICAL AUXILIARY MOTOR CONNECTIONS

* General engineer, Westinghouse Electric & Manufacturing Co.

sate will be used as circulating water in the condenser of the evaporator to condense the make-up water. The exhaust steam from the house turbo-generator and the remainder of the exhaust from the boiler feed pumps and forced draft fans will be condensed in a barometric condenser, which will use as condensing water the main condensate. This combination is designed to heat the feed water to about 200 deg. F. without waste of water or heat.

To transfer the load electrically between the house turbo-generator and the main bus, the simplest arrangement is direct parallel operation between the 2300-v. house service bus and the main 12,000-v. bus through the 2500-kv.a. transformer bank. This arrangement, however, is open to the objection that disturbances on the main bus will directly affect the house service bus, with the danger of interrupting service to the various auxiliaries. Even if relays are used to disconnect the house turbo-generator from the main bus under abnormal conditions, they will not operate quickly enough to prevent trouble, and the frequent separation of the main bus and the house service bus in the case of momentary disturbances on the distribution system is objectionable.

To overcome this difficulty, a flexible tie should be obtained between the main bus and the house turbine generator by the use of a motor generator set, consisting of an 1100-hp., three-phase, 2300-v., 60-cycle, 880-r.p.m. induction motor, and a synchronous generator rated at 750 kw., 2300-v., 3-phase, 60-cycle, 80 per cent power factor, 900 r.p.m. The 1100-hp. motor will be fed from the 2500-kv.a. transformer bank, while the generator will run in parallel with the house turbo-generator as shown in Fig. 1. The motor will be of wound rotor type, and will have additional secondary external resistance to give a slip of 5 per cent. Provision should be made so that in case of emergency the motor generator set can be bypassed.

As the motor and generator of this motor generator set (or the heat balance set) will be of the same synchronous speed, there will be no transfer of power between the main and auxiliary bus with the house turbine adjusted for the same frequency as the main turbine. The condition of heat balance that would require all the electrically driven auxiliaries to be supplied from the house turbine would then be met by operating the house turbine at a frequency corresponding to that of the main bus. For a change in condition involving less steam from the house turbine for heating the feed water, a part of the load can be transferred to the main bus by adjusting the governor of the house turbine and dropping the speed to the desired value.

Under abnormal conditions, such as would result from disturbances on the high tension system, it will require a drop in frequency corresponding to the slip adjustment of the main motor generator set to shift the load from the set to the house turbine. A further drop in speed of an equal amount will be required before a corresponding additional load will be picked up by the house turbine.

For motors and control equipment used to drive the auxiliaries in large stations, ruggedness and reliability are essential. The power requirements of the auxiliaries are so great that the whole design of the auxiliary power supply should be handled from the viewpoint of a large substation located in the power house. The current which can flow under short circuit conditions is so large that standard industrial control in most cases is inadequate.

It is also desirable to locate the control equipment in one place rather than have it scattered all over the station. With these considerations in mind, all squirrel cage motors of 2300 v. should be started from a starting bus, using standard, oil circuit breakers, one for starting and one for running. Two auto-transformers, rated at 865 kv.a. for six minutes, with 40, 50, 60 and 70 per cent taps, would be used to feed a starting bus. The breakers will be electrically operated from push buttons at the motor and will be located in a cell structure. Figure 2 shows a typical diagram of the connections. The motor is started from a push button station at the motor, having "start," "stop" and "run" buttons. On pushing the "start" button, the starting breaker is closed and the motor accelerates. By pushing the running breaker, the starting breaker is tripped and the running breaker closed. As the disconnecting

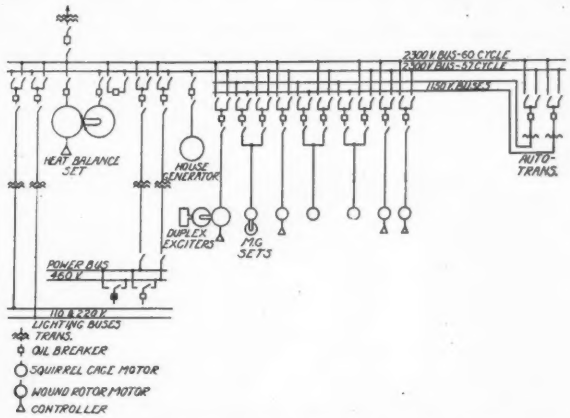


FIG. 3. GENERAL LAYOUT OF THE AUXILIARY POWER SUPPLY

switches are to be mounted in a structure, signal lights and a small switch will be located on the structure underneath them. If it is desired to change the disconnecting switches, the lights will indicate if the breakers are open, and by operating the small switch the closing circuit of the breaker may be opened so that the disconnecting switches can be operated without danger. A white light will show when the control circuit is interrupted and will be an aid in preventing the control circuit being left open after the change is made.

The general layout of the auxiliary power supply for the station is shown diagrammatically in Fig. 3.

The coal handling equipment has an assumed capacity of 200 tons per hr. and will be in duplicate. Each equipment will require three motors, one 20 hp., 870-r.p.m. motor for the conveyor, one 50-hp. 870-r.p.m. motor for the elevator, and one 50-hp., 875-r.p.m motor for the crusher. All motors will be of the wound rotor type and the power supply will be at 440 v. The control equipment should comprise a contactor equipment for each motor, so interlocked that the motors in each set will automatically start or stop in rotation when the proper button is pushed at any one of several

remote push button stations. A double throw switch will be provided on each board, by means of which the interlocks can be thrown out and the motors adjusted independently.

Each boiler will have an underfeed 17 retort stoker with double roll clinker grinder. Each stoker will be driven by a 20-hp., 1200-300-r.p.m., 230-v., d.c. motor. The speed range to be obtained by a shunt field control. Each roll of the clinker grinder will be driven by a 10-hp., 1200-300-r.p.m., 230-v., d.c. motor. The control equipment will consist of a drum controller with a protective panel having a contactor, overload relay, and fused knife switch. The drum controllers will be mounted on a panel which is equipped with the necessary instruments for efficient boiler operation. The 230-v. direct current supply can be taken from either of two 200-kw. induction motor generator sets.

Each low-pressure turbine element discharges into two condensers having 25,000 sq. ft. of cooling surface, making a total of 100,000 sq. ft. These condensers will be served by four condensate pumps, three air pumps and three circulating pumps. The circulating pumps are to be driven by 600-hp. wound rotor, 2300-v., 505-r.p.m. motors. Wound rotor motors will be used to reduce the starting current. The control equipment will consist of a primary oil circuit breaker and a hand operated drum controller, arranged to close the circuit breaker on the first step and trip the breaker on the return to the off position.

The condensate pumps are to be driven by 100-hp. squirrel cage motors, 1160 r.p.m., while the air pumps will be driven by 100-hp., 690-r.p.m. squirrel cage motors. The motors will be started from the starting bus through oil circuit breakers.

There will be two 350-kw. 250-v., 1180-r.p.m. dual drive exciters, each of which can supply the total excitation. These units are to be arranged for both motor and turbine drive. The turbine governor is to be so arranged that in case of the failure of the motor drive the turbine will pick up the load. The motor will be 530-hp. wound rotor type, with contactor control for secondary.

The miscellaneous equipment should comprise: (1) two service pumps driven by 40-hp., 440-v., 1750-r.p.m. squirrel cage motors with float control, (2) two sump pumps driven by 15-hp. 440-v., 1160-r.p.m. squirrel cage motors with float control, (3) two weigh larry motors, 10-hp. 440-v. wound rotor type, (4) two air compressors driven by 110-hp. 2300-v., 870-r.p.m. wound rotor motors, (5) two traveling screen motors, 7½-hp. 440-v., 1160-r.p.m. of the squirrel cage type, and (6) two battery charging motor generator sets, each consisting of a 25-hp. 440-v. motor driving a 15-kw. 125-v. d.c. generator.

Surrounding Corroded Steel Stacks With Concrete

By John V. Schaefer

THE conservation of self-supporting steel stacks which have corroded to the danger point by encasing them with concrete has become a well-established practice. Engineers and owners of power plants should know of it. To demolish an otherwise serviceable stack simply because the steel shell has lost its strength by corrosion when at comparatively small expense and without even shutting down the boilers it may be converted into a permanent concrete stack would, in the light of present knowledge, be a mistake.

Rather than tear down a steel stack which was in condition requiring renewal, causing shut-down of the pumping station at South Works, Illinois Steel Co., South Chicago, 1919, it was decided to use the cement-gun in reconstructing the stack. By coating the outside with reinforced cement-gun concrete, a new self-supporting stack has been built upon the existing foundation.

This steel stack was 175 ft. high by 9 ft. diameter. A reinforcing net-work of sufficient strength to make the new stack self-supporting without any help from the existing stack was built up of rods and wire mesh and secured to the existing foundation bolts. A cement-gun was then used to shoot guncrete or gunite, as it is variously called, through the reinforcing mesh against the existing steel shell to the required thickness. A mixture of sand and cement hydrated in the nozzle was applied with an air pressure of about 35 lb. The guncrete is 18 in. thick at the base, tapered rapidly to 6 in. just above the bell base and then gradually decreases to 4 in. at the top.

The cement-gun remained on the ground. The dry mixture of sand and cement was blown through the hose by aid from a compressor working at about 50 lb. pressure. Water was forced through the water hose lines at a pressure great enough to give a pressure at the nozzle in excess of the air pressure. The operator worked upward from the bottom, finishing as he went, so that at the end he was 175 ft. above the gun and material was forced up to him at that point.

All the work was done without interrupting the use of the stack. The guncrete was applied when the stack was too hot to permit holding the hand against it. The breeching extending from the side of the boiler house to the stack was also encased with 3 in. of guncrete while it was so hot that water thrown against it boiled. The guncrete was kept thoroughly sprinkled until set. The effect of the hot stack seemed to be that of steam curing and after being in use for nearly 3 yr. the guncrete is everywhere sound and shows no cracks.

Figure 1 shows this stack as it appeared when completed. So successful was the work that others have taken advantage of this method of saving stacks that were otherwise serviceable. A list of such stacks rendered permanent, for which data has been available to the writer, is given below. Doubtless there are others.

STEEL STACKS REINFORCED WITH CEMENT

Key No.	No. of Stacks	Size: Diam. Inches	Size: Height Feet	Year
1	1	115	175	1918
2	5	90	125	1918
3	2	68	110	1918
4	2	60	100	1920
5	3	68	110	1920
6	6	90	150	1921

Remarks

1. This was at a pumping plant which could not be shut down. Work was done without interrupting service in July during very hot weather.

2. Two of these were out of commission when encased and hence cold. The other three were in regular service and hence at normal temperature.

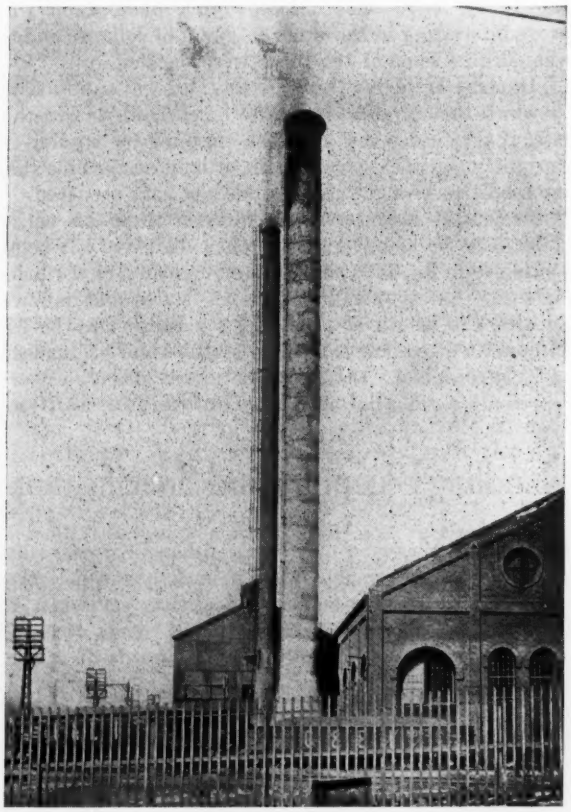


FIG. 1. STACK COMPLETELY SURROUNDED WITH REINFORCED CONCRETE JACKET

3. These were done in December with weather so cold that work had to be protected against freezing. Both stacks were in regular service.

4. Work done in July. One was in service, the other out of commission. This was a repeat order from same people who have No. 1. These stacks sometimes have temperatures running up to 1200 deg.

5. Repeat order same as No. 3. Work done in December. Weather cold. Work had to be protected against freezing. One cold, the other two in service.

6. These are now under construction, four being finished. The first one was done in January. Weather was cold. Stack was out of commission. Sufficient fire was made in stack to bring steel plate above freezing point and work was protected against freezing. The other three were in commission and the remaining two will be done while in commission.

The above list comprises 19 stacks including two not yet finished. Seventeen of these are in daily use. Eight of them have gone through two winters. None of them show any cracks, except a few surface glaze cracks, which do not penetrate perhaps more than ⅛ in. Some were encased while cold, some while hot, and all of them are in daily service and are perfectly sound.

Figure 2 shows progress on stacks described under key No. 5.

This is to be noted. Every one of these stacks was lined with fire brick to the top. Every one of them had adequate vertical reinforcement and very substantial horizontal reinforcement consisting of wire mesh supplemented with rods. Every one of these was shot with cement-guns, insuring dense, sound concrete throughout, without any chance for voids or defective material.

Engineers and owners of power plants having good steel stacks which need repair or replacement because of extensive corrosion can confidently come to this firm conclusion, that when it comes to the matter of encasing an otherwise serviceable self-supporting steel stack properly lined, there can be no question whatever but that it is entirely practical to do this if the work is entrusted to competent operators, and if the design is correctly worked out. In doing this, it will not matter whether the stack is in service or not in service when the work is done. The new stack will not crack. It will not need painting. It will resist corrosive gases from without, and if any portion of the original stack corrodes from within, it will not matter, as the new cement-gun made stack does not in the slightest degree

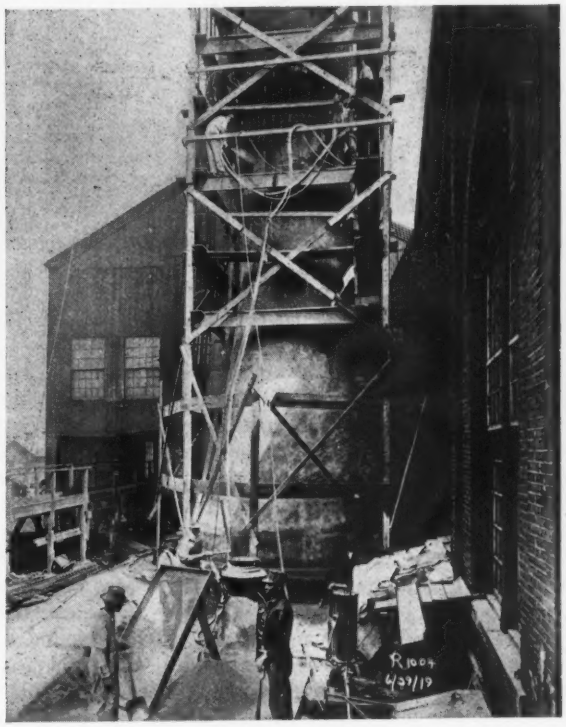


FIG. 2. SHOOTING A CEMENT JACKET AROUND STEEL STACK

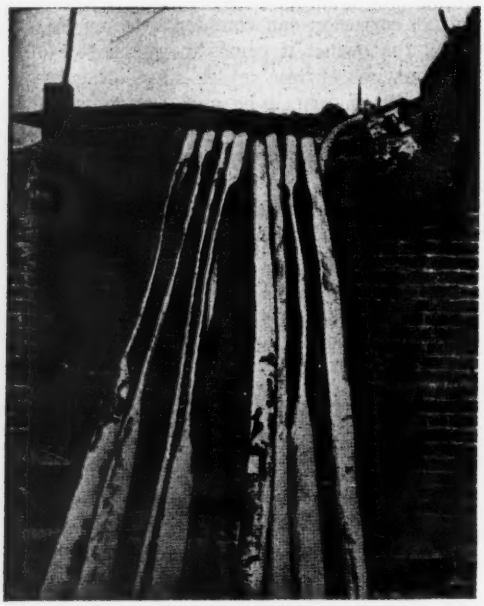
depend on the original steel shell for its stability or permanence.

There remains to be mentioned the fact that all of the work can be done without interruption of service, and this alone may sometimes be worth more than the price of the stack.

Collapsed Boiler Tubes

By Clark C. Bradford

AN instance of the peculiarities attending boiler accidents came to the author's attention last year when he had occasion to make an internal inspection of a horizontal return tubular boiler, which was found showing evidence that the water in the boiler had at some time been allowed to reach a low level. Generally speaking, to allow the water in a steam boiler to fall below a predetermined safe working level causes the exposed tube ends and seams to leak, and it is not unusual to find it possible to have the boiler placed again in a serviceable



COLLAPSED AND BUCKLED TUBES RESULTING FROM LOW WATER

condition by expanding the tube ends and calking the seams to make them tight.

The boiler mentioned in this article was supplied with feed water by direct connection with the pressure main. The operator had various duties to perform, requiring periodic absence from the steam plant, and due to the practically unvarying load on the boiler had found it possible to adjust the feed water valve and the oil burner to maintain a fairly constant water level and steam pressure. During a temporary absence of the operator, the water in the main was shut off without previous warning, due to necessary repair to the water supply system, and when the attendant returned to the boiler he found no water in sight in the gage glass, and a test of the feed connection showed no water pressure in the supply pipe.

The boiler was shut down and it was found that the water had fallen to a point about 18 in. above the bottom of the shell. A great many of the tubes were therefore found not covered with water and, of course, leaked considerably, the rear head seam also requiring to be calked tight. Up to this point, the proceeding is what may be termed "regular," but when 17 of the tubes were found collapsed, some partially and others totally, a condition arose that was "irregular," as it is not common to find tubes collapsed in cases of low water.

The collapse in this instance appears to be attributable to the fact that considerable soot had collected in some of the tubes and caught fire, causing overheating of the metal and reducing its power of resistance to a point where collapse was possible. Many of the tubes were badly buckled, 40 requiring renewal. These, together with the 17 that collapsed, represent a repair cost of considerable size, the tubes being 3 in. in diameter and 16 ft. long. The accompanying photograph will prove interesting in showing the extent of collapse and to what degree some of the tubes were buckled.

In many accidents there are revealed ways and means by which their prevention would be effected, and in this case, if the feed water had been supplied by a pump in conjunction with a storage tank, it is quite possible that the condition brought about would not have occurred.

Prolonged absence of an operator from an active boiler is to be looked on with much disfavor, not being conducive to its safe operation and contrary to the principle of "Safety First." In some states and municipalities, the length of time which a boiler may be left without an attendant is fixed by statutes and ordinances, as it is recognized that a boiler under steam pressure represents a potential hazard.—California Safety News.

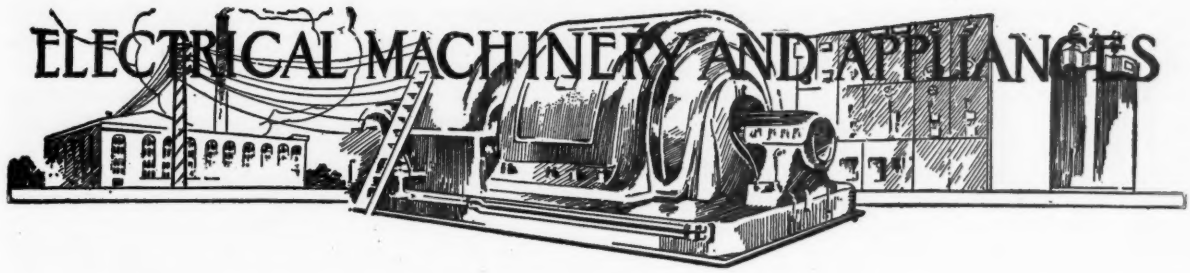
Handling Blueprints and Specifications

By J. B. Dillon

IT IS not always convenient, neither is it necessary that workmen should wash their hands before they handle blueprints and specifications, yet when we consider that many otherwise excellent prints are made worthless by careless handling, a few words of caution will not be amiss. In using the word "workman," I refer to officemen as well as those on the outside. Pick up a loose leaf binder containing specifications and prints in some offices and what do you find? Parts torn off, the entire page crumpled, and what remains is so dirty that the words and figures cannot be read. The result is that the former excellent guide is now useless.

The same conditions are found on the outside, only the smear is different, owing to the fact that oil and grease form part of the dirt as found on the outside papers. If it is necessary that one consult these valuable helps with hands so soiled that to attempt to handle will be sure to besmear the paper, then the idea is—cleanse the hands first. It is not necessary to stop for a manicure. If the hands are only slightly soiled, lay a piece of paper between the print and that part of your hand that rests on the print; it is often necessary to trace wiring or piping lines with a pointer, and to rest the hands on the print assists in keeping on the right line and not getting off the tracks at a junction. If a little caution were used, these prints would last for years as a reference, but as it is, they do not last long enough to serve present needs. The natural deduction when one finds these papers crumpled and torn is that those who are slovenly in handling such valuable articles will be slovenly in their work.

A FOOL ENGINEER and his boiler may not "soon part," but there is reason to believe that they may "go up" any moment.



Design of Industrial Electrical Distribution Systems—I

TYPES IN GENERAL USE AND ADVANTAGES AND DISADVANTAGES OF EACH. BY V. E. JOHNSON

THE LAST few years have seen an enormous increase in the use of electricity for industrial purposes. New applications and new processes are constantly being developed; there is today scarcely any manufacturing method that cannot be improved or cheapened by its use. This remarkable growth has made increasingly important the matter of the proper distribution of energy within the plants themselves.

The great diversity of electrified industries, each requiring a more or less individualized distribution system, makes the subject at best very broad; but fortunately these various applications are governed by the same underlying principles, while the special features required for each class of service can be separated into groups having similar characteristics.

FEATURES OF SYSTEM

THE DESIGN of an industrial distribution system must incorporate in general the features outlined below:

A. Power must be supplied continuously—i. e., there must be freedom from interruption.

B. Power must be distributed economically—interest, depreciation, maintenance and operation costs must be so balanced as to produce the lowest possible total charge.

C. Power must be distributed safely, not only with reference to the equipment itself (which subject would properly come under B above), but also with reference to the safety of the operators.

D. Power must be distributed conveniently, that is, in such a way as to reduce to a minimum the cost of switching operations and to permit the instant adaptation of the power to the needs of the manufacturing process.

E. The system must be so planned as to permit growth—and to provide as far as possible for convenience in making alterations.

F. The system should be simple, logical and standard—so that changes in personnel will not seriously affect the operation.

G. The apparatus used should be of such type and make that no difficulty will be experienced in making replacements; and every effort should be made to secure interchangeability of parts, in order that the repair part stock may be reduced to the minimum.

Freedom from interruption has been given first place in the foregoing tabulation; because, after all, this is the object of the entire installation. It can, however, not be treated as a separate subject, as it is apparent that if B, C, D, E, F and G are given proper attention, A will follow of itself.

Economical distribution of power has entering into it a great many factors. In general, the principal ones are as follows: (a) voltage frequency and phase of current used; (b) system of distribution such as underground, conduit, open, etc.; (c) layout of conductor network; (d) size of conductor used—[determined by (a) and (c)]; (e) special apparatus used—such as cabinet boxes and protective devices; (f) closely related is the matter of properly metering the consumption of power.

On account of the greater flexibility and convenience the majority of installations are alternating current, although there are a great many applications that require the use of direct current. Thus, for example, in paper mills, the constant speed machinery is usually driven by alternating-current motors while for the adjustable speed drive on the paper machines themselves direct current is used. This is a matter that will, in a measure, take care of itself, being determined either by the requirements of the manufacturing process, or else by the nature of the available power.

EFFECT OF VOLTAGE ON SIZE OF CONDUCTOR

(V) Voltage	(A) Amp.	(V.A.1.73) Watts	(V/22) Voltage Lost	Size of Conductor in Circular Mils.	Nearest Larger Comercial Size	Power Lost	Percent of copper required
110	200	38,104	5	760,000	800000 CM.	1732	100
220	100	38,104	10	190,000	0000	1732	25
440	50	38,104	20	47,500	# 3	1732	6¼
550	40	38,104	25	30,400	# 5	1732	4
2200	10	38,104	100	1,900	#16	1732	1/4

Based on a balanced 3-phase 3-wire line, 1000 ft. long 1 way; neglecting reactance. Loss is based on 1/22 line loss, this odd value being selected for convenience in figuring. It will be noted that 110 v. distribution requires 400 times as much copper as a 2200 v. system with equal loss. Also note that the size wire obtained for 2200 v. is too small to be used in practice.

Frequency and phase would not properly be determined by the designer of the distribution system. If some choice is to be exercised regarding these characteristics, it may be well to bear in mind that 60-cycle three-phase current has become almost a standard in this country, and that apparatus of this type is more readily obtainable from the manufacturers.

This brings us, then, to the matter of voltage—and even here the choice is somewhat limited. If direct current is used, the voltage of the central station would govern in the case of purchased power (unless motor generator sets were employed) so that really the only condition requiring consideration would be that where the power was produced locally.

In the latter case, the three voltages to be considered are 115, 230 and 550. If lighting is to be done with direct current, the choice would fall on either 115 v. or

else on 115-230 v. 3-wire. The latter would be more desirable if considerable amounts of power are involved; in fact, many engineers prefer these voltages under all conditions. The use of 550 v. is accompanied by considerable personal hazard—and it is a question whether it is justified except in large plants where due to existing conditions it is not practical to install motor generators near the point of use. Some idea of general practice as regards 550 v. motors may be obtained from the following data from the stock sheets of a large manufacturer:

	Number of different styles stocked	
Type of Motor	230 volt	550 volt
Shunt wound—constant speed.....	41	6
Compound wound—constant speed..	28	7

This would indicate that high voltage direct-current systems are not widely used in this country. It would be safe to assume that any system large enough to require 550 v. for direct-current distribution would be more satisfactorily fed by alternating current.

For alternating current the available industrial voltages are 110, 220, 440, 550 and 2200. In the table is given the relative economy in copper obtained by using these various voltages; values given therein are based on the factors indicated in the heading.

It will be seen from the foregoing that 2200 v. is vastly more economical in the use of copper than the lower voltages. This is, however, in no sense of the word a net gain for several reasons.

1. The insulation of 2200-v. systems is more expensive than that of lower voltages.

2. Apparatus for 2200 v. up is more expensive, and more is required to accomplish a certain function. For example, current and potential transformers must be used with instruments and relays.

3. The economy in copper disappears when the amounts of power to be distributed are so small that mechanical factors rather than the carrying capacity limit the size of the wire used.

4. Due to manufacturing limitations, it is impossible to secure many types of machinery for 2200 v. (for example, fractional horsepower motors), so that in many cases the use of this high voltage for the main distribution would require an auxiliary low voltage network.

5. The personal hazard due to the use of such a high voltage requires the use of protective apparatus for safety purposes, the cost of which very often more than offsets the saving in copper.

The use of 2200 v. would therefore be limited to the following general classes of plants:

1. Extremely large plants (such as steel mills) covering large space and using enormous quantities of power. Usually a supplementary low voltage system would be provided in such cases.

2. In plants using moderate quantities of power, but utilizing this to drive only a small number of motors of comparatively large size.

3. Distribution systems supplying plants made up of many widely separated buildings (as for instance dynamite factories) and having therefore approximately the characteristics of a city installation.

At the other extreme of the available range of voltages, namely 110, the copper required for the transmission of comparatively small amounts of power is an effectual bar to its use. If, however, the energy is to be used for lighting, the power demand being merely incidental, this low voltage is very convenient.

As a practical matter based on the action of numberless industries, the choice narrows down to 220, 440 or 550 v. Between these three a tabulation shows the following comparison, percentages being used in all cases to indicate the relations:

	220 v. Per cent	440 v. Per cent	550 v. Per cent
Weight of copper.....	100	25	16
Cost of installation.....	100	100	100
Cost of apparatus motors, etc.)	100	100	100
Pieces of apparatus required for a given operation...	100	125	125
Availability (promptness of shipment—ease of obtaining)	100	80	70
Completeness of line available	100	90	90
Personal hazard	100	175	200

Many of the foregoing percentages cannot be determined in any scientific way and are merely general estimates, but they serve to show at a glance the features of each system.

There seems to be no clear line of demarcation between the fields to be covered by the different voltages, but in a rough way, the following expresses the opinion of a number of engineers:

Voltage	110	220	440	550
Horsepower	0–200	50–1000	500–2500	1000–4000

These figures do not cover cases where the motors are few and very large, nor where very small units are used; nor is it representative of widely scattered systems. It covers the average plant employing largely 5, 10 or 25 hp. motors with a few of 75 and 100 hp.

As an added deciding factor, it might be added that a plant using 440 or 550 v. would need the services of experienced plant electricians, as the personal hazard would hardly justify the dependence on the ordinary factory help for making minor repairs, replacing fuses, etc.

Circuit Layout

In plants using 220 v., the lighting could be from balance coils; but, generally speaking, it would be more desirable at any voltage to separate the lighting circuits from the power circuits. Thus, in case of a failure of a motor feeder at night, a separate lighting circuit would permit repair work to be carried on. Also, in plants which operate days only, a considerable economy is effected by killing the power transformers at night—leaving only the lighting circuits alive.

The choice of a system of distribution, the design of the feeder and branch layout, and the determination of the proper size of conductor are dependent on one another to a large degree; but for purposes of design analysis, they can better be considered separately.

An industrial distribution system consists broadly of two parts: (1) The network in the plant itself; (2) connecting lines between different buildings, and between the plant and the source of power.

There is no question but that a rigid metallic conduit installation is the best for the interior wiring of the

plant, except in a few isolated cases as enumerated below.

(a) In locations that are extremely hot. Here the rubber insulation is rapidly destroyed and it is often better to use slow burning wire mounted on porcelain knobs, and so installed as to be protected from mechanical injury.

(b) In locations where there are corrosive fumes which would destroy the iron pipe in a short time. Various protective coatings are available and their faithful use helps a great deal. In extreme cases, however, it may be necessary to resort to the use of fiber duct, care being used to install it so that it does not suffer mechanical injury.

(c) In location where the conduit would be constantly exposed to the action of corrosive fluids dripping or flowing over it. The remedy might be the same as for (b) above—and at other times the use of lead cable in fibre or clay duct would be preferable. In these cases, the installations become very complicated—as it is difficult to make them mechanically sound; it is generally better, when such extreme conditions are to be met to change the location of the leads to a drier place or to provide some sort of a "roof" over the pipes.

For the connecting links between the various buildings, the engineer must choose between overhead and underground construction. The latter is much to be preferred as it is:

1. Not affected by weather conditions.
2. Not exposed to lightning.
3. Does not occupy valuable space.

If, however, the buildings are widely scattered, the cost of the underground construction becomes prohibitive; the engineer will have to balance the probability and seriousness of interruptions against the cost of installation, and decide each case on its merits. If an

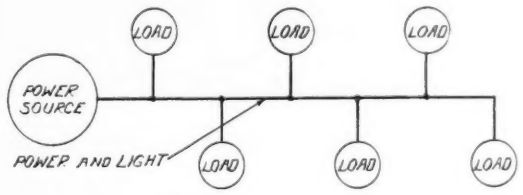


FIG. 1

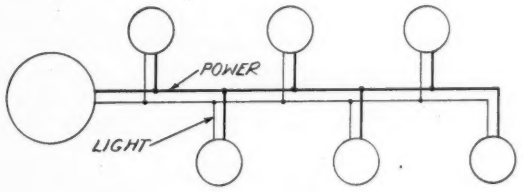


FIG. 2

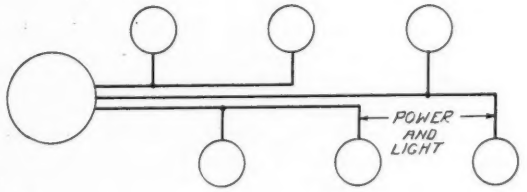


FIG. 3

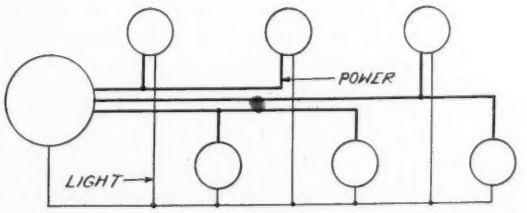


FIG. 4

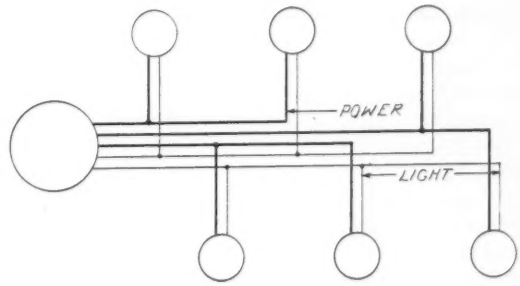


FIG. 5

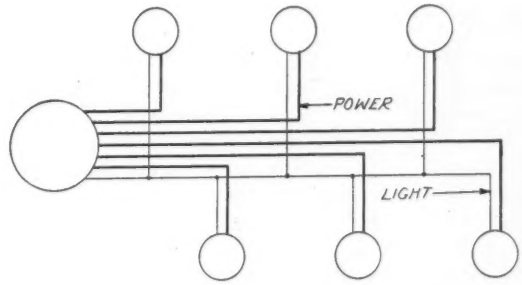


FIG. 6

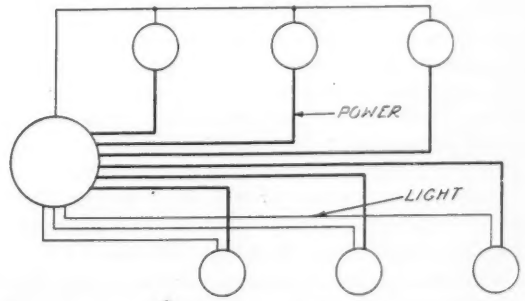


FIG. 7

FIG. 1. THE SINGLE FEEDER SCHEME. FIG. 2. ILLUSTRATING USE OF ONE POWER FEEDER AND ONE LIGHTING FEEDER. FIG. 3. APPLICATION OF MULTIPLE FEEDER SCHEME. FIG. 4. USE OF SEVERAL POWER FEEDERS AND SINGLE LIGHTING FEEDER. FIG. 5. MULTIPLE POWER FEEDERS AND MULTIPLE LIGHTING FEEDER. FIG. 6. ILLUSTRATING USE OF ONE POWER FEEDER FOR EACH DEPARTMENT AND A SINGLE LIGHTING FEEDER FOR ALL DEPARTMENTS. FIG. 7. SAME AS IN FIG. 6 BUT WITH MULTIPLE LIGHTING FEEDER.

interruption would mean heavy spoilage of material, or excessive "starting up" cost, it may be that even the heavier expense of the underground construction is justified.

There are several general layout plans in use differing in cost and reliability. The tabulation below gives a list of these, the cheaper methods being enumerated first. The brief comments show the distinctive features in each case.

METHODS OF DISTRIBUTION

1. ONE FEEDER from source of power with branches to each department and used for light and power. (Figure 1.)

Failure of one feeder would shut down the entire plant and leave it in the dark. Cheap—but unreliable and hazardous (because the sudden failure of lights may cause injuries from the machinery rotating under its own momentum.

2. One power feeder and one lighting feeder. (Figure 2.) Better than No. 1 but lacks flexibility. Failure of one feeder, either light or power shuts off entire plant during periods when light is required.

3. Several feeders—each supplying both light and power to a group of departments. (Figure 3.) This is not so bad if the departments grouped are of such a nature that they could not in any event operate independently. Lighting from the power mains is undesirable, however.

4. Several power feeders each supplying a group of departments. One lighting feeder supplying all departments. This is a satisfactory arrangement, as the possibility of interruption affecting more than one group is small. See Fig. 4.

5. Several power feeders and several lighting feeders supplying groups of departments. (Figure 5.)

This is more expensive than No. 4, but more reliable. It also permits the temporary cross connection between lighting feeders to permit repairs without shut-downs.

6. One power feeder for each department. One lighting feeder for all departments. This is a very popular arrangement and will be ample in the great majority of cases. Shown in Fig. 6.

7. One power feeder for each department. Lighting feeders may supply groups or individual departments, depending on size and location. (Figure 7.)

While the foregoing plans and accompanying sketches primarily show the methods of feeding whole departments or buildings, the general layout can be used in supplying individual motors from the panels. From the panel boards lines may be run to individual motors or to groups of motors, depending on the size and operating conditions. P would then indicate main panel boxes for power or light, and L either motor or lighting loads.

Under the heading of "feeder and branch layout" must be considered also the main headings D, E and F, namely, the convenience, flexibility and simplicity of the system; these factors must be borne in mind when laying in the various lines, in the plans for the installation.

LOCATION OF LOAD

LOCATION of the motors and other power consuming devices will be determined by the nature of the industry, and the leeway allowable is usually small. Every effort should be made to have them in a clean, dry and accessible place. Thus, in a wet basement all motors should be up on a foundation; in a steamy room they should be kept as far from the source of the moisture as possible; locations under possibly leaky pipes should be avoided; it should not be necessary to crawl through belts or over shafting to make inspection.

It should be borne in mind that any motor may need to be removed at any time, and the installation so planned that this can be accomplished without disturbing other apparatus.

In the location of controlling apparatus, such as compensation, starters, fuses, etc., a great deal is left to the designer of the distribution system. Before deciding on any definite place, questions such as the following must be considered:

1. Can this apparatus be operated without danger from belts, gears, etc.?

2. Is there room enough to repair or inspect it?

3. Is the contemplated position the best possible from the standpoint of the machine operated? In the case of an emergency, can the motor be promptly stopped, and can the starting operation be properly controlled?

5. Is this apparatus located so that in case the plant is to be enlarged it can remain undisturbed? This applies particularly to panel boxes and main control apparatus.

6. Is the location such with reference to the apparatus controlled, that a new man would not make a mistake such as closing the wrong switch or pulling the wrong fuse? Is the relation between a device and its auxiliaries self-evident, or must dependence be placed on memory or on more or less confusing marks?

The location according to the preceding principles, not only of motors and controlling devices, but also of panel boards, conduit runs, manholes and other parts of the distribution system, is a factor in the design that must not be neglected.

U. S. CIVIL SERVICE COMMISSION announces an examination (receipt of applications to close June 21), for master mechanic (machinery), to fill a vacancy at Raritan Arsenal, Metuchen, N. J., at $2000 to $2400 a year, and vacancies in the Ordnance Department at Large or other branches of the service throughout the United States in positions requiring similar qualifications, at these or higher or lower salaries. After 6 mo. satisfactory service appointees may be allowed the increase granted by Congress of $20 a month. Duties will consist of supervising operation and maintenance of mechanical equipment in use in the Ordnance Department. The mechanical equipment at Raritan Arsenal consists of locomotive steam rollers, stationary boilers and machine shop. Competitors will be rated on the following subjects, which will have the relative weights indicated, on a scale of 100: (1) physical ability, training and experience. Applicants must have served an apprenticeship or its equivalent as machinist, and have had at least 5 yr. experience on the repair, maintenance and operation of equipment similar to that outlined above. They must not have reached their sixty-fifth birthday on the date of the examination. In view of the retirement act, should the appointing officer so request certification will not be made of eligibles who have reached their fiftieth birthday. Apply for Form 1800, stating examination title.

Safety Features of Industrial Lighting*

INSTALLATION OF CORRECT EQUIPMENT AND PROPER SUBSEQUENT MAINTENANCE FACTORS OF VITAL IMPORTANCE. BY S. G. HIBBEN†

VARIOUS State Codes relating to the lighting of factories and mercantile establishments bring us face to face with a new safety factor—illumination. This is one of the least understood, yet most vital subjects that have to do with economic, humane employment and development of labor, and as our knowledge of better lighting increases, our appreciation of its influence on industrial operation increases in proportion.

In discussing industrial lighting fixture equipment, and particularly its maintenance, we have entered upon an argument disclosing much that is vital in the accomplishment of all three of the desiderata of successful industrial operation, viz., production, speed and safety; and, since production depends upon the other two, or since all three are really synonymous, any arguments applying to the maintenance of a grade of illumination satisfactory for *safety*, will apply equally well to the others.

Good or bad lighting depends upon two outstanding factors. Bare incandescent lamps, or unshielded glaring illuminants that not only do not illuminate but cause a contraction of the pupillary opening of the eye and resultant decrease in seeing ability, form one of these factors. More or larger bare lamps only aggravate this trouble and increase the hazard; the solution is found in the proper use of a good reflector, or a shielding fixture.

The second factor is the matter of insufficient light, and this is largely influenced by lamp renewals, reflector and lamp cleaning, and the colors of surroundings, or whatever would be involved in maintaining the original installation up to its initial efficiency. It is this important phase of applied illuminating engineering that we will discuss.

Insufficient illumination unquestionably reduces visual acuity, decreases the speed of muscular action, confuses the mind, and leads to accidents.

Granting, for a moment, that good illumination is largely dependent upon the care of the lighting equipment, let us see what valuation may be put on poor maintenance, in other words, what is the high cost of poor light. Figures that in general agree with insurance statistics (if they err, it is upon the safe side) show that the total annual serious accidents in industrial plants in the United States amount to 25,000 per year. That is the minimum figure. Out of this 25,000 we find 15 per cent chargeable to poor illumination—either unshielded poorly directed light, or insufficient light. Now, based upon the average amount of employe's compensations paid, the equivalent lost time of each serious or fatal accident traceable to faulty illumination is 850 weeks, or the total annual time lost is over 3,000,000 weeks, roughly equivalent to the working lifetimes of 1000 men. If these men were earning $25 per week, then practically $80,000,000 in wages are lost annually, through improper lighting. If we add to this staggering sum the doctors' bills, medicines and losses of production we arrive at astonishing figures!

One does not often think about the fact that the intensities of artificial light in industrial plants are much below the daylight intensities. We find daylight in factories running from four to approximately 50 foot-candles; general artificial lighting in factories for even fine factory work has this year been in the range of 4 to 12; medium factory work between 2 and 9, and sometimes down to ½ or ¼ foot-candles for indoor passageways. Places like stairways, and the positions where accidents are the most prevalent are usually most poorly lighted and if daylight conditions here were reproduced even in the most meager way—even if we only approximated daylight conditions we could reduce accidents materially because statistics show that the largest majority of accidents occur in the night shifts. The percentage is about two to one—two accidents under artificial lighting compared to one accident under daylight conditions.

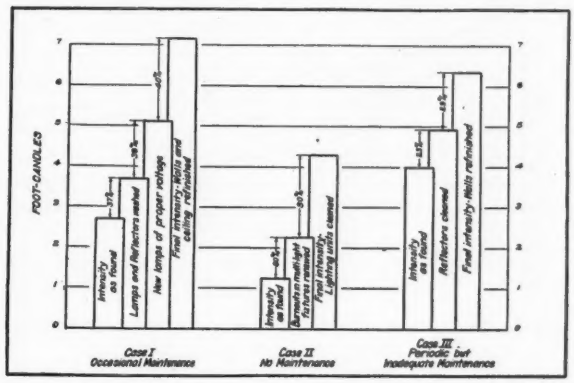


FIG. 1. THREE TESTS ON LIGHTING SYSTEMS WHICH ILLUSTRATE THE NECESSITY FOR REGULAR AND ADEQUATE MAINTENANCE

How do the manufacturers regard good lighting? Increased production—79 per cent of the manufacturers say, is their excuse for good lighting. Decreased spoilage, 71 per cent say, is their reason. Fifty-nine per cent of the manufacturers say that fewer accidents constitute their reason for good lighting, etc.

Offhand, the manufacturers admit, without argument, that in half of the cases they would have fewer accidents if they had better illumination.

Now, it has been shown that the total cost of accidents, the total disability payments, and the total lost time of industrial operators in the United States amount to more than the total cost of artificial illumination. We should ponder over that fact. The total cost of artificial illumination in the United States is exceeded by the cost of accidents and the loss of production resulting from poor lighting, and yet 59 per cent of the manufacturers already agree that poor lighting is directly or indirectly responsible for these accidents. Surely then, it is logical to preach the doctrine of improvement, and the folly of inertia.

Data of reputable insurance companies prove that artificial lighting is connected in some way with accidents. In one class of labor during July and August there occur out of a maximum of some 95 accidents, about

* From paper presented before a meeting of the National Safety Council.

† Illuminating Engineer, the Westinghouse Lamp Co.

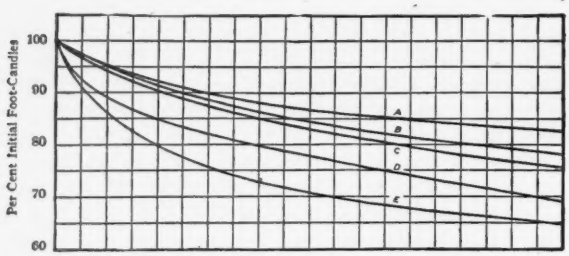
60. The rate rises in October, November, and December, falling off in January, February and March, as the days grow longer, and down to a minimum again in May, June, and August, when daylight is a maximum.

Other items, such as poor ventilation, low temperatures, etc., undoubtedly enter into these figures, but in tropical latitudes nearly this same ratio is found to exist.

Similarly, the majority of the accidents that do occur in the dark seasons occur when the daylight is insufficient.

Maintenance of Systems

Now, it can be shown how maintenance is responsible for good light, and conversely what poor light we will get when we do not consider maintenance. The first thing to do to get good illumination and to reduce the danger of industrial accidents is to look to the interior



A—Dome Enameled Steel
B—Bowl Enameled Steel
C—Dense Opal Glass
D—Prismatic Glass
E—Light Density Opal Glass

FIG. 2. EFFECT ON ILLUMINATION INTENSITY OF COLLECTION OF DUST ON LAMPS AND REFLECTORS

finish of the rooms or the factories in which we operate. This is termed "painting for light." In other words, we say that ordinary white paint has a reflection value of 82 per cent. Consider the ceiling of a room finished in gray-white and with a reflecting value of about 75 per cent, then three-quarters of the light falling on the ceiling surface will be reflected. Now, if we were to neglect that fact, and were to paint our walls and ceiling medium gray, for instance, which would reflect 46 per cent of the light, we have cut our available usable illumination practically in half. Down in the red and dark colors we get reflection coefficients that range in value to about 30 per cent. Hence, one of the first things that will lead up to better illumination and fewer accidents will be the attention given to interior finishes of the buildings.

This question of light-colored interiors is pertinent. Not only must we use light-colored paints if we wish to obtain efficiency, but we must clean the paints or must maintain them. Some of us have worked a great deal in the steel mill districts where perhaps the cheapest thing in the factory would be whitewash, and yet it was the rarest thing that we could find. We would rarely find a steel mill whitewashed, and yet the illumination of such a plant could frequently have been increased 20 per cent by a coating of whitewash on black walls. Large expanses of pure white surfaces directly before a workman's eyes are not advisable, as neither are unshaded windows, but a sensible use of both can produce remarkable improvements.

Cleaning is essential in maintaining lighting efficiency. If a typical reflector that has been in service several weeks be wiped, its candlepower in a downward direction is increased from 1000 to approximately 1350, with corresponding increases in other directions. If we go a step further and thoroughly wash the unit with soapy water and ammonia, its downward light is increased to about 1500 candle-power. Obviously, a neglected lighting fixture cannot properly perform its work, and the ones that show dirt are in many cases preferable to those that do not, for they will probably be cleaned oftener.

Coming back to industrial plant lighting, we may see that though some fixtures are affected more than others, yet all suffer so much that after two or three weeks' time the light output is reduced to 85 per cent of its original amount, or less. If we consider the inverted type of glass bowl, or the semi-indirect types, we find a still more astonishing condition. Merely a thorough washing results in 26 per cent more usable illumination and the cost of this cleaning as compared to the investment and operating expenses, is small, scarcely reaching 30 per cent of the latter. We have a slogan "Water is cheaper than watts," that might well be printed on the card of every efficiency expert.

Comparing the depreciation of illumination in the office with that in the factory, we note that the factory units suffer more. This is reasonable because we find more dust, and usually an oily dust, in the atmosphere of the factory. In a dirty building, after three weeks of neglect, the illumination may drop from 4.0 to 2.0 foot-candles.

If we assume or admit that cleaning of lighting fixtures and of light-reflecting surroundings is essential to efficiency, then why don't we clean? Is the cost prohibitive? It cannot be considered so, in comparison to the results secured. In a typical large building having glass lighting reflectors and rather elaborate commercial fixtures, we find that out of a total annual operating cost of lighting equipment amount to $14,438 the cleaning and maintenance is represented by $4633, or about 32 per cent which may be taken as a fair proportion.

Expressed in the terms of an evaluation of the working man and his possible output, the cost of good lighting is perhaps one-tenth to one-quarter of one per cent. If we can add to the workman's output, or eliminate lost time represented by not more than 2 min. per day, then the value of his output in that short length of time will equal his share of the cost of lighting for the entire day. Expenditures for oil are sometimes greater than for light—are we then evaluating the machine higher than the man?

In order to show what could be done with a neglected lighting installation, three factories were taken which had conditions that are found all too frequently. Case 1 was found with 2.6 foot-candles of average illumination intensity. Washing the units increased this illumination 37 per cent—to 3.6 foot-candles. Replacing old lamp bulbs with new lamps of the correct voltage-rating produced another increase of about equal amount while finally a re-painting of the interior resulted in a final intensity of over 7 foot-candles, all without increasing the power consumption in the slightest. Cases 2 and 3 of this same experiment showed similar gains that resulted from intelligent maintenance, all adding weight of testimony to the fact that *it pays to clean.*

Water Wheel Driven Alternaters

MECHANICAL CONSIDERATIONS INVOLVED IN THEIR DESIGN AND CONSTRUCTION. BY E. MATTMAN

A WATER WHEEL carrying full load runs with a normal peripheral speed of about half the spouting velocity of the water. At zero load, however, if the governor fails to operate, the speed of the water wheel will increase considerably. Hence, alternators driven by reaction-type turbines are designed for an overspeed of approximately 85 per cent, and whenever possible are tested at the specified overspeed at the factory to insure satisfactory balance and to guard against defects in materials. Impulse wheels are usually designed with a lower ratio of normal peripheral speed to water velocity and may require that the rotors be built for overspeeds up to 100 per cent.

An overspeed run is usually maintained for about one minute. Nothing is to be gained by running the machine for a longer period at maximum overspeed, as any defects would show up at once, and it does not seem good judgment to submit a machine to abnormal stresses any longer than necessary.

Rotors are designed to have a reasonable factor of safety throughout when running at the maximum overspeed. The shafts are carefully figured for stress and deflection, taking into account the critical speed. The spiders are pressed or shrunk onto the shafts with proper allowance to maintain a tight fit when running at overspeed.

SPIDERS

SMALL ROTORS up to about 55 in. diameter have spiders built up of 1/16-in. sheet steel laminations, as

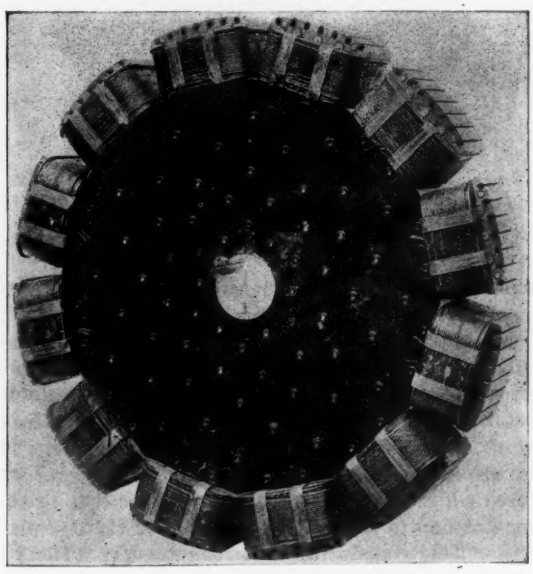


FIG. 1. SPIDER BUILT UP OF 1/16-IN. SHEET STEEL LAMINATIONS

shown in Fig. 1. To insure the maximum possible uniformity of material, each lamination is revolved one pole pitch relative to the previous lamination during assembly. The dovetail slots receiving the poles are punched, and drifts are used in several of these dovetail slots during the assembly to assist in building up the punchings as evenly as possible. The laminations are held together axially by pressed-in rivets with heads spun over on each end. The bore and keyway for receiving the shaft are machined after the spider is assembled.

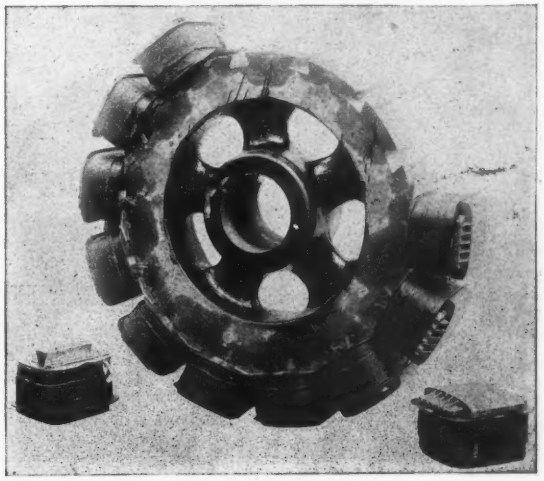


FIG. 2. CAST STEEL SPIDERS FOR MEDIUM SIZE ROTORS

For rotors of medium size from 55 up to about 150 in. diameter, cast steel spiders are ordinarily used, as shown in Fig. 2. The castings are annealed and inspected for blowholes and other imperfections. If apparently satisfactory, they are carefully tested for ultimate strength, elastic limit, elongation and reduction of area by means of test coupons cast integral with the rotor spider. During the process of machining, the casting is again carefully inspected for seams, cracks and similar defects. The dovetail slots, by which the poles are held in position, are finished with milling cutters to secure the greatest degree of accuracy possible on the angles, fillets, etc. It would be cheaper to slot out these dovetails, but with this process there would be a possibility of imperfect fitting, sharp fillets and injurious tool marks.

For very high speeds, this construction would require a rim of such depth that the casting might be unsafe, since proper annealing would be difficult with ordinary foundry practice. In such cases a plate spider is resorted to, as shown in Figs. 3 and 4, which is built up of hot-rolled open-hearth steel plates approximately 2 in. thick. Each slab from which the plates are cut is tested for physical properties by bending and tension tests, the test specimens being taken from the worst place on the slab. The individual plates are rough turned, and faced on the sides. They are marked with regard to the direction of rolling and the top of the slab and, while assembling, each plate is revolved one pole pitch from the preceding one. The plates are clamped together with throughbolts, a number of which are fitted into reamed holes.

For large spiders requiring deep rims, above 150 in. diameter, where thick rolled steel plates are not obtainable, or where the spider would be too large for shipment, a laminated spider rim is used, as shown in Fig. 5. These laminations consist of 1/16 in. sheet steel held to the cast wheel spider by dovetails fitted closely into milled dovetail slots on the end of the spider

FIG. 3. PLATE SPIDER FOR HIGH SPEED ROTORS

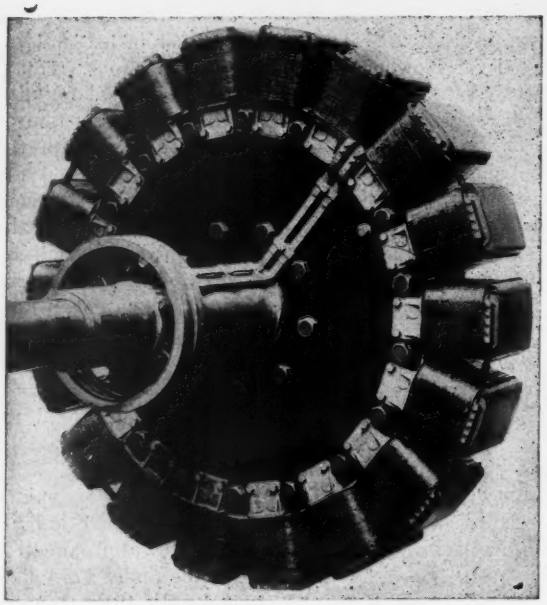


FIG. 4. PLATE SPIDER BUILT UP OF HOT ROLLED OPEN HEARTH STEEL PLATES

arms. The laminations are clamped together between heavy end plates with throughbolts of such a size as to make reaming unnecessary. The joints between the laminations are staggered in as many axial planes as practicable, to obtain the maximum possible strength.

Large spiders, greater than 180 in. diameter, must be split for shipment. Spiders with laminated rims are held together with bolts, the rim and poles being assembled at destination. Spiders with cast rims are fastened together with shrink links in the rim and bolts through the hub; such rotors can usually be shipped with most of the poles assembled at the factory.

Field Poles

Field poles are built up of 1/16-in. steel laminations held together either by rivets or by throughbolts which clamp the punchings tightly between end plates. The nuts of these throughbolts are countersunk into the end plates. The upper coil supports on the sides of the poles are used to hold the field coil ends in place against centrifugal force. They are either riveted to the pole tips or else are integral with the end plates. The lower coil supports are commonly made hollow so that metal can be poured into specially provided pockets when found necessary in order to secure proper static or

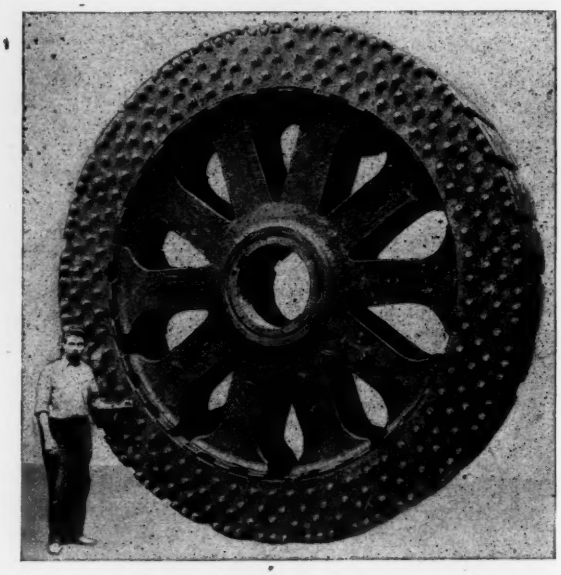


FIG. 5. LAMINATED SPIDER RIM BUILT UP OF 1/16-IN. SHEET STEEL

dynamic balance. These coil supports are fastened to the spider by bolts and are provided with slots so that any radial play that may develop in any field coil, after the overspeed test, can readily be taken up. Each pole is provided with a dovetail which fits snugly into the dovetail slot on one side and leaves a space for the insertion of two tapered steel keys on the other side. The poles are fastened to the spider by driving the keys with a force sufficient to give a pressure somewhat greater than that due to the centrifugal force of the assembled pole and field coil during the overspeed test. The keys are then cut off flush with the spider rim.

A slight saving in rim depth may sometimes be obtained by using two or more dovetails per pole. This practice is not, however, to be generally recommended, as the dovetails may become unequally loaded, due to slight inaccuracies in the machining or unequal driving of the dovetail keys. These disadvantages can be somewhat alleviated by partially splitting the pole body into as many sections as there are dovetails per pole.

Field Coils

Wherever possible, field windings are made of copper strap wound edge, as this makes a strong coil. Where the voltage is too high to permit the use of strap, insulated wire or ribbon is used, the latter being wound on edge. These coils are given a bakelite treatment which improves their insulation characteristics and makes them stronger mechanically. On high-speed machines, and especially on those with long cores, it often becomes necessary to hold the coils in place with coil braces to prevent them from spreading out under the action of centrifugal stresses.

Dovetail Tests

Extensive tests have recently been made to determine the comparative strength of different shapes of dovetails, as well as to see how the actual test results compared with the calculated strength of the dovetails and slots, and particularly to determine whether it is necessary to combine stresses in different planes in making calculations. For instance, should bending and tension be again combined with shear? Seven different pulling tests were made with samples of the dimensions shown in the table, samples *1* to *5* being dovetails, and samples *6* and *7* dovetail slots. Samples *1* to *5* were built up of 1/16-in. steel laminations and samples *6* and *7* were made of hot rolled open hearth steel plate. The dovetails were pulled while engaged in dovetail slots of such proportions as to make the dovetails fail first. The dovetail slots were tested with dovetails of such size as to bring about failure of the slots without changing the form of the dovetails. Check tests were made on regular tension test pieces which were cut from the edges of the plates of which the dovetail slots were made. The elastic limit was determined by an extensometer. From these tests the following conclusions were drawn:

a—There was no marked difference in strength per running inch between the 0.75 in. long dovetail and the ones of 1.5 in. length. The test results can, therefore, be considered as representative for dovetail slots of greater length, such as are ordinarily used in practice.

b—All punched dovetails, without end plates, failed by buckling, as shown in Figs. 6 and 8. There was no difference in strength between the one rivet and two rivet dovetails. The dovetail with end plates failed by tearing, as shown in Fig. 7. It began to yield with about the same pull as the dovetails without end plates.

c—The results obtained compared closely with calculations, and showed that the assumed plane of greatest stress was correctly chosen, and that stresses in planes at different angles, such as bending and shear, should be combined in order to get the maximum resultant stress.

d—There was no apparent difference in strength between the two shapes of dovetails. For a given pull the 60-deg. dovetail takes up approximately 25 per cent less depth and about the same amount more in width than the 150-deg. dovetail. Thus it was thought best to retain the present standard shape, namely the 60-deg. dovetail, especially since the 150-deg. shape has certain disadvantages, such as narrower keys and smaller fillets, as well as the required centering of the poles circumferentially.

Special Designs

Rotors of somewhat higher peripheral speeds can be built by resorting to the use of removable pole tips. In this design the rotor spider and pole bodies are integral, and are made of one solid steel casting, or several cast or forged slabs, or of the required number of rolled steel plates properly bolted together. The pole tips can be held on in various ways. The most common arrangement is that shown in Fig. 11, where the tips are fastened to the pole body by a number of screws or bolts, which are sometimes made of nickel steel. In Fig. 12 is shown a special arrangement in which the pole tip consists of a number of steel plates which are inserted into recesses in the outer part of the plates which form the spider and pole bodies. These pole tips are held to the pole bodies by the throughbolts. Another method of fastening the pole tips to the pole bodies is shown in Fig. 13. For this arrangement the pole body must be either round or square or nearly so. The pole

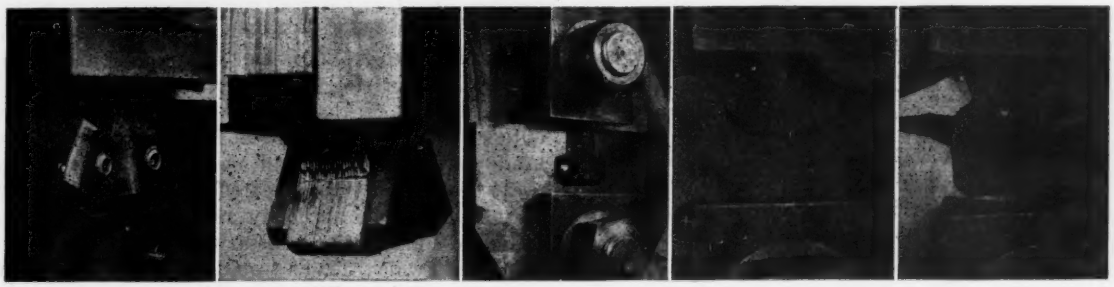


Fig. 6. Laminated dovetail failed by buckling
Fig. 7. Laminated dovetail with end plates
Fig. 8. 150-deg. laminated dovetail failed by buckling
Fig. 9. Lips of 60-deg. dovetail slot turned up
Fig. 10. 150-deg. dovetail slot

Dimensions of Test Dovetails and Slots

Sample	Degrees	Depth In.	Width In.	Length In.	Rivets	See Fig.
1	60	2	3.5	1.5	1	..
2	60	2	3.5	1.5	2	6
3	60	2	3.5	1.5	End Plates	7
4	60	2	3.5	0.75	1	..
5	150	2⅞	2⅞	1.5	2	8
6	60	2	3.5	1.5	..	9
7	150	2⅞	2⅞	1.5	..	10

tip is provided with a very coarse thread of a diameter about equal to two-thirds of the diameter or width of the pole body. It is either screwed into the pole body, as illustrated in Fig. 13, or is provided with a tapped hole and screwed over the pole body, the pole tips in this case forming part of the body. A laminated outer pole face may be used with the construction shown in Fig. 13, which is one solid piece of steel, but this is not possible with the poles shown in Figs. 11 and 12, which are made up of steel plates. This pole face may be fastened

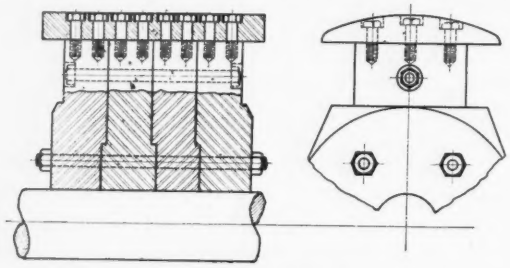


FIG. 11. POLE TIP FASTENED TO POLE BODY WITH NICKEL STEEL BOLTS

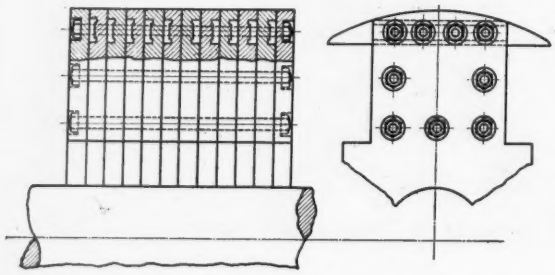


FIG. 12. STEEL PLATES OF POLE TIP INSERTED INTO RECESSES OF BODY PLATES

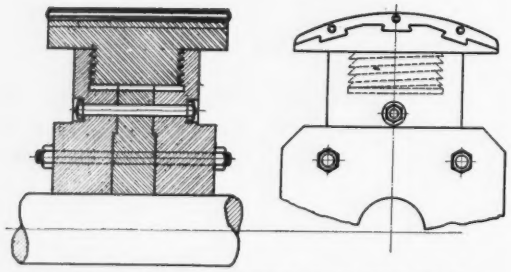


FIG. 13. POLE TIP SCREWED INTO POLE BODY

to the solid part of the pole tip by dovetails, as shown in Fig. 13.

All these constructions are considerably more complicated and consequently more expensive than the ordinary designs with dovetailed poles. They also require more machining of a special nature and must, therefore, undergo more painstaking inspection. In the case of steel castings or thick cast slabs, the danger of faulty material remaining undetected is particularly great, on account of the large size and intricate shape of the castings involved. This danger is, of course, lessened in designs using forged slabs or plates, which involve, however, much more machining. These designs have been used abroad more frequently, probably on account of the greater amount of skilled help available at reasonable prices there.—The Electrical Journal.

Organization

By W. A. Darter

TO DO efficient work in any engineering undertaking it is absolutely necessary to have an efficient organization. It is foolishness for the head of an organization to try to look after the details of any operation, for while he is looking after the saving of a penny, he may be taking the time that would save him, in some other undertaking, a dollar. It is just as foolish for one to try to manage something beyond his understanding when he could be saving the pennies by doing something he does understand.

An organization is a human machine by which work is carried on. The better the organization, the more efficient the human machine becomes, and consequently greater work can be accomplished with the same cost and energy.

The general organization tree will consist of a manager, superintendent, and various subheads; and every department under the subheads should have a head. The best organization is one that has a distinct connecting link between the various parts. It must be possible for the coal roller or helper to reach any other head through the right channels, as well as the manager to reach the coal roller or helper.

Each head of the department must have a given authority, and must be backed up by the department head above him. This given authority may vary a great deal, yet for the most efficiency each department must have enough authority and leeway to give it the initiative and interest necessary. Each department has its details, which details would have to find their way to higher officials. Whatever this given authority is to the different departments, it is always necessary for the man above to stand back of the head, whether right or wrong. If this is not done, or cannot be done, then the authority should be taken away from the heads.

Every organization should have its rules. These rules should be the expression of the employes as well as the employer; and they must be based on fairness to all. The employes should know why each rule is set forth, and the importance of following it. Each rule should be executed and followed as near as possible; for, after a rule has once been broken without a cause then it becomes hard to enforce it; the employer will lose grip and the results are disastrous.

An organization makes it possible for the manager to train and rate his men. It also makes it possible for the men to know their places and do their parts more efficiently. Since every man is responsible for his part, he can be given credit according to the way he does it. Also, when there happens to be a vacancy either by resignation or sickness, there is always one that is next in line, and the change creates less confusion and dissatisfaction.

Contented employes make a good organization possible. There are several ways that help make an employe contented. The most important is to see that every employe is getting a fair salary according to the work he does. This salary must be at least a living wage or the employe can never be contented. Some employers will argue that a certain place will not pay a living wage to the cheapest help. If this is true, the place should either be absorbed into some other place

of the organization or else done away with. Good playgrounds, libraries, cafeterias, and benefits, will help to content an employe, but if his or her salary is below par, this welfare work is lost to a certain extent.

In every good organization there should be some way to reward an employe for extra service given. This extra service may be given in the form of long years in service, devotion to the work, advancing of new and better working conditions; and the rewards may be given in the form of increased salaries, a per cent of profits earned, or so much for each good thing accomplished.

In every organization the leaders of the departments must have charge of the men in their departments. Unsatisfactory results are sure to follow the manager or boss who goes around his leaders and directs the men. The men must be reached through their leaders unless emergency demands otherwise. This is necessary and efficient, because the manager does not know the details of the superintendent's work, neither does the superintendent know the details of the chief engineer's work.

The ideal organization is one in which there are no lost motions. Every man knows his part, and there is always one prepared to fill a vacancy. All the men pull together and there are no misunderstandings. It is one in which every man from the helper up is given a hearing and consideration from the man higher up. It is an organization in which the men will work for the good of the whole, even though it becomes necessary to sacrifice self.

Some Power Plant Troubles

CARELESSNESS OR LACK OF SYSTEM ON THE PART OF AN ENGINEER OFTEN RESULTS IN SERIOUS BREAKDOWNS. BY H. A. JAHNKE

SOME engineers and firemen are quite careless at times regarding the condition of the apparatus under their charge, and it frequently occurs that a shut-down of the apparatus, if not of the whole plant, on this account is the result.

These troubles are more apt to occur in a one man plant than in those plants where a number of men are employed, as frequently the engineer in a one man plant has other duties to perform besides those in the engine and fireroom.

It is the writer's intention to show where and how some of these engineers are at fault and how these faults can be remedied.

FAN BEARINGS RUNNING DRY

I REMEMBER one plant in particular where the engineer had other duties to perform besides firing and looking after the engine, pumps, etc. These extra duties were oiling the line shaft bearings, motor and fan bearings, also keeping them in repair. This engineer used to have much trouble with the fan and motor bearings running hot, due to lack of lubrication. He had no certain time of attending to certain jobs. It was often the case when a bearing needed attention or when about to do some repair work that trouble would occur in the power plant and as a consequence the fan or motor bearings, etc., that also needed attention were forgotten, until his attention was called back to the matter. This carelessness or thoughtlessness caused many shut-downs of the different departments in the plant.

Had this engineer made a practice of doing a certain job at a certain time, this trouble would not have occurred.

I have in mind another engineer in a small plant who does the entire oiling of line shaft, motor and fan bearings, also taking care of any repairs that are needed on any of this equipment. This man has very little trouble, which is due to the fact that he employs a system in doing this extra work, in fact, he always has sufficient spare time to read his engineering magazines and books.

The fan and motor bearings are looked after each morning after he has the fires under the boilers in good condition and the steam starts to rise. After all the fan and motor bearings that need oiling each morning are attended to and the engine oiled, it is time to start the engine.

The line shaft bearings are oiled at regular times and repairs made when they are needed.

BLOWER BELT BREAKS, DUE TO CARELESSNESS

IN ANOTHER instance where forced draft was used, the blower was driven by a belt from a counter shaft. One day, as the fireman was shoveling coal into the furnace, fire and smoke fired back out of the furnace, burning the fireman's hands and face so badly that he was laid up for some time. After the smoke had cleared away and an inspection had been made, it was found that the blower belt was broken.

In this case, it had been known for some time that the belt was in poor condition, but the repair had been delayed until it finally let go at a time when it was needed badly, as before the belt was repaired the plant had to shut down due to lack of steam pressure. This was all due to carelessness on the part of the engineer and fireman. As the plant operated only during the day, the belt could have been repaired some morning or during the noon hour when the plant was idle.

Still another instance was where a centrifugal belt driven pump was used for circulating water from a hot water tank through an open heater. This system operates in the following way which may be of some interest. There are two tanks connected together by a pipe as shown in Fig. 1; cold water runs into one of the tanks from the city main, and then runs to the other tank through pipe A. From this tank the centrifugal pump receives the water and forces it through the heater from which the water runs back into the tank by gravity, as the open heater is located a few feet higher than the top of the tank. In this way the water is circulated a number of times through the heater and becomes quite hot. Exhaust steam from the engine and other apparatus is used in the heater.

The hot water in these tanks is used in the wash room of a large laundry as well as for boiler feeding. No exhaust steam is wasted in this plant as all is condensed in the heater.

One day it was noticed that the hot water supply

in the laundry was getting colder and colder, but this was not given any attention until a number of poor washings were turned out. After an investigation was made, it was found that the belt on the circulating pump was torn, hence no water was circulating through the heater. Since there was no hot water, the plant had to shut down until the belt was repaired. In this case, also it was known for some time that the belt was in poor condition but nobody paid any attention to the matter until the belt broke.

No Overflow on Water Tanks

In a certain plant, two large water tanks are located above the boiler room. These tanks receive the water from the city water mains. The water is controlled by two automatic valves, but at times these valves stick and the tanks overflow. As there are no overflow pipes, the water runs over the boilers and boiler room floor. This trouble could be remedied by equipping the tanks with overflow pipes but nobody seems to think of this until their attention is called to it.

A Dangerous Practice

In a plant where there is one boiler and an engine it is costomary, in case it is necessary to shut down the engine, due to a breakdown or accident for any person who may be near the engine room to shut down the engine should the regular engineer not be at hand.

One day when it was necessary to shut down the engine to place a belt on the pulley, the engineer was not at hand, so one of the men from the shop stopped the engine. In the meantime, the engineer arrived and inquired of the man who shut down the engine whether he had opened the drain valves at the bottom of the cylinder. The man replied that he did. When all ready to start again, the engineer opened the throttle valve, when there was a loud knock in the cylinder. Examination showed that condensation had collected in the cylinder and steam pipe during the time the engine was idle.

All parts of the engine were examined, but nothing found broken so the engine was started; but this was a narrow escape and a wrecked engine might have resulted. In this case, the engineer took it for granted that the man had opened the drain valves after the engine was shut down, so he did not examine them to make certain that they were open before starting, hence the engineer would have been to blame more than anybody else, had the engine been wrecked.

Where necessary that the engineer be absent from the power plant frequently and it is necessary to shut down the engine, some employe from the factory should be instructed thoroughly how to stop the engine provided there is no fireman in the plant.

No doubt, in the above instance, the man was under the impression that he had opened the valves. It will be noticed, in Fig. 2, that the drain valves at the bottom of the cylinder are arranged as shown at A-B. There also is a drain valve in the bottom of the elbow of the exhaust pipe as shown at C, and it was this valve that the man had opened, thinking he had opened the drain valves of the cylinder.

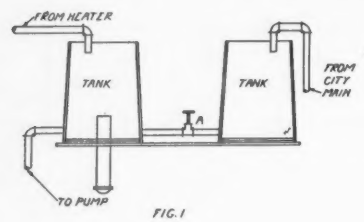


FIG. 1

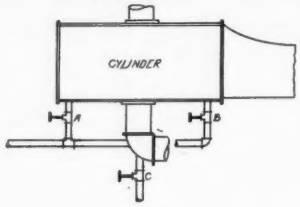


FIG. 2

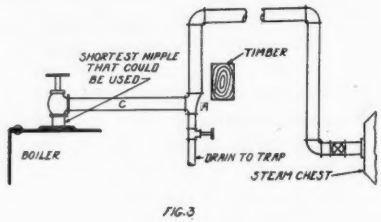


FIG. 3

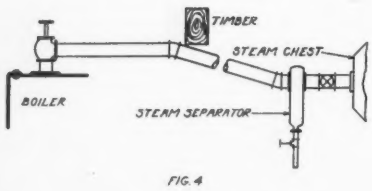


FIG. 4

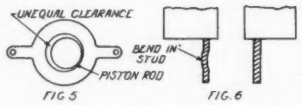


FIG. 5

FIG. 6

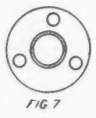


FIG. 7

FIG. 8

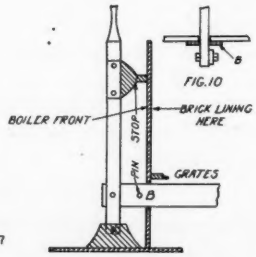


FIG. 9

FIG. 10

FIG. 1. OPEN HEATER PUT OUT OF COMMISSION BY A BROKEN BELT. FIG. 2. SHOWING ARRANGEMENT OF DRAIN PIPING ON CYLINDER. FIG. 3. PIPING ARRANGEMENT WHICH CAUSED TROUBLE. FIG. 4. PIPING SHOWN IN FIG. 3 REARRANGED TO OVERCOME DIFFICULTY. FIG. 5. UNEQUAL CLEARANCE AROUND PISTON ROD. FIG. 6. SHOWING BENT STUD. FIG. 7. GLAND TROUBLE DUE TO LOOSE NUTS. FIG. 8. FOREIGN MATTER IN JOINT CAUSED TROUBLE IN THIS SHAKING BAR. FIG. 9. SHAKING BAR STOP LOOSENS BRICKWORK IN BOILER FRONT. FIG. 10. SHOWING HOW TROUBLE DUE TO ARRANGEMENT IN FIG. 9 WAS REMEDIED

Faulty Pipe Work

A small vertical steam engine was installed in a plant to drive a line shaft. This engine gave more or less trouble due to water in the cylinder which kept the engineer busy opening and closing the drain valves a number of times during the day's run. Nobody in the plant seemed to know what caused the trouble.

The boiler furnishing steam to the engine was located some distance away, hence much of the steam was condensed before reaching the cylinder and it was thought that this caused the trouble. The management was under the impression that this could be remedied by

covering the pipe, which was not covered at the time. After the pipe was covered the trouble was nearly as bad as before.

The piping from the boiler to the engine was arranged as shown in Fig. 3, in order to pass over a timber in the building. It was this loop over the timber that caused most of the trouble, as much condensation would collect in the elbow A and pipe C, although there was a drain at the bottom of the elbow A. The piping was changed to that shown in Fig. 4, also connecting a steam separator into the line near the engine. This remedied the trouble entirely.

Packing Gland Stud Bend

At one time, I took charge of a high speed steam engine and the first time I packed the piston rod I noticed that it was impossible to adjust the nuts on the gland studs so as to obtain equal clearance around the piston rod and bore in the gland as shown in Fig. 5. When I had an opportunity to examine the gland and rod more closely, I found that one of the gland studs was bent as shown in Fig. 6. There was considerable play between the studs and stud holes in the gland and whenever the gland holes came over the highest point in the bend on the stud, it would push the gland to one side. It was thus, of course, impossible to adjust the stud nuts so as to bring the gland in a position so the piston would travel in the center of the gland bore. As it was not safe to straighten the stud, which had been in service for a long time, I removed it and replaced it with a new stud. After this, there was no trouble in adjusting the gland as it should be.

In another instance, one of the nuts on the stud of a packing gland which was equipped with three studs as shown in Fig. 7, would work loose. This would allow the gland to rub against the piston rod, wearing the bore in the gland out of round and a flat spot on the piston. This trouble was much worse when a soft packing was used, which would expand considerably when heated, so the gland nuts had to be loosened up more or less to allow for this expansion. During the night, when the piston and packing cooled, the gland nuts were very loose and then the next morning, after the engine was running, the nut would work back on the threads. The gland would then rub against the piston rod. I remedied this trouble by placing lock nuts on all the studs. These lock nuts were about half the thickness of the regular gland nuts.

Why the Grates Operated Hard

I have hand stokers in my plant. One day, one side of the stoker started to work hard and I was under the impression that clinkers or a piece of slate from the coal had gotten under some working part of the stoker. As I could not shut down the boiler until the next Sunday, I let it go until then, but when examining the grates of the stoker, I found nothing there that could possibly make this work as hard as it did. Then I commenced to look for the trouble in another place and found that it lay in the joint where the grate bar connects to the shaking bar, as shown in Fig. 8, at A. Some foreign matter got between the two bars in such a manner that it remained there and caused the joint to bind, hence it worked hard. The puzzling part of it was that nobody had thought of examining this part before blaming a clinker or a piece of slate for all the trouble.

Why the Front Furnace Lining Was Ruined Frequently

In a plant where shaking grates are in use and the shaking bars always remain in place, there is a stop on these bars which bumps up against the boiler front when the grates are level. The stops are arranged on the shaker bars as shown in Fig. 9. Frequently in trying to get the grates level, and due to a clinker or a piece of slate between the grates, the fireman had to use much force to bring the shaking bar into position so the grates were level. The stops on the bars would frequently strike the boiler front quite hard, which in turn would loosen up the front brick lining. After this the fire brick would commence to drop out, making it necessary to repair this part of the lining often. To remedy this trouble, the stops on the shaking grate were removed and holes drilled through the grate bars as shown at B, and a pin driven into this hole. When this pin was close up against the boiler front, we knew the grates were level. Should the fireman have to use force on the bars at times and accidentally strike the pin hard against the boiler front, there is not as much danger in loosening the brick lining as when the stops were used. In drilling the holes into the grate bar, it was located in such position that when the pin was close to the boiler front the grates were level. The idea is shown in Fig. 10 at B.

Reliability of Steam Driven Boiler Feed Pumps

By C. M. Evans

Reliability of steam-driven boiler feed pumps (either single, duplex or turbine driven) is a feature which causes practical steam-plant men to consider them favorably. Although the steam-driven pumps are considerably less economical than either the motor or the mechanically driven, they will operate whether or not the prime mover in the plant is running—whenever there is steam in the boiler. This characteristic is often of importance because there may be times when the prime mover is inoperative when it is necessary that water be fed into the boiler.

Again, where a motor-driven feed pump is used, there is another link—the generator—inserted in the chain between the feed pump and the boiler.

The disadvantages just recited, of the mechanically and motor-driven feed pumps, disappear if any auxiliary steam-driven feed pump, which is used as a stand-by, is installed.

In this connection, the following recommendations of R. J. S. Pigott, who is mechanical engineer of the Interborough Rapid Transit Co. are of interest.

"Boiler-feed pumps are usually the duplex outside-packed plunger type, or the three-stage or four-stage centrifugal. Occasional installations of motor-driven triplex pumps are made, but are undesirable. The principal feature required is reliability, which at once gives the steam-driven apparatus the precedence. The duplex direct-acting type was, until recently, used almost exclusively, but it is now being replaced by the turbine-driven centrifugal pump."

Acetylene Generator Explosion

REPORT OF ACCIDENT AT PLANT OF MOORE SHIPBUILDING COMPANY, OAKLAND, CALIFORNIA. BY LETSON BALLIET

ON THURSDAY morning, March 3, 1921, a large acetylene generator exploded, completely wrecking the building in which it was housed. That no one was seriously injured was due to the fact that the attendant was outside of and a few feet away from the building. The cause of the explosion has been the source of considerable popular gossip and speculation.

The conditions were as follows: At 3:00 p. m., March 2, this generator was cut out of service and its mate, which had just been recharged, was turned into the service mains. The attendant (not a technical man) opened the 2-in. drain valve to drain it of water and "sludge" preparatory to recharging. He states that after draining it he refilled the generator with water (about 300 gal. is his estimate of the amount) but did not charge the hopper with carbide. At 4:20 p. m. the quitting whistle blew. The operator shut off the water, closed the door of the generator house, and rushed for the gate with the other employes.

At 7:30 the next morning, when the operator returned to work, he filled the hopper with carbide. He states that he had it filled at 8:15 a. m. At 9:55 it exploded. It had not been cut into the service. It was filled with carbide in the morning and with water the night before. It was supposedly idle and standing ready to replace its mate when it had become empty.

After the explosion, examination showed that it was not caused by a backfire for it was completely valved off the line, and its carbide charge was still intact in the hopper and perfectly dry. The 2-in. gate valve to the sewer was wide open, leading to the belief that the operator had been in such a hurry to get away at 4:20 p. m. the night before that he had forgotten to close it. The operator, however, claims that he closed it and put in 300 gal. of water. If he did not close it, the 300 gal. of water ran through and down the sewer, leaving the generator without water.

Another theory is that if the operator did close the drain valve before rushing away at 4:20 p. m. the night before, somebody might have smelled the acetylene odors rising through the sewer pipe into which the tank had been drained, and thinking it was a gas leak had opened the valve, believing he was stopping the leak. The rush of the water probably washed away the sludge in the sewer pipe and thus stopped the smell for the time. In any event, the outlet pipe was open when examined immediately after the explosion, and evidently there was no water in the generator. The bottom was full of wet sludge because there was a thick slime for several feet around the generator when we reached it after the explosion.

There was a crash of the splintering building and a puff of flame that instantly enveloped the whole building and extended probably 50 or 60 ft. high and wide, but it was over in a second. There was no fire. The paint was not even blistered on either of the generators, nor on any of the piping. The yard fireman was but 100 yd. away at the time, and thinking that a fire might follow he pulled a 40 gal. extinguisher in front of the wrecked building and wet it down. But there wasn't a charred board or splinter in the wreckage, proving that there was no fire except the puff of flame with the explosion.

The inside of the generator was marked with a carbon (soot) deposit. The outlet pipe and the 2-in. gate valve when removed was found to have soot on the inside of it. There could have been no water in it, or there would have been no soot in the drain pipe, nor in the valve, nor below the water level inside the generator.

What happened was this: The 300 gal. of water had run out in the sewer through the open drain valve (however it got open); the bottom was covered with wet sludge. The draining of the tank the day before, the refilling with water, the water overflow and drain valves both open must have admitted considerable air into the generator. Also the removal of the top when the operator filled the carbide hopper would admit air in the generator. It would even create a draft through the open drain valve to open end of the hopper.

When the operator filled the hopper with 200 lb. of carbide, more or less of the fine carbide sifted through and dropped upon the wet sludge on the bottom. Here it began to generate gas from the moisture and possibly some of it reached a heat of 900 deg. in the absence of the water. This generated gas remained practically at atmospheric pressure by escaping through the drain pipe to the room. The drain pipe opened over a hole in the concrete floor that connected with the sewer.

This condition filled both the generator and the building that covered it with acetylene gas mixed with the air, resulting in an explosive mixture at ordinary atmospheric pressure.

The operator claims that the gage was at zero when he looked at it a short time before to be sure it was not working and ready to be turned on. Manifestly the gage would be zero if the drain valve was open.

When the hot calcium-carbide absorbing moisture from the slimes on the bottom of the tank reached the temperature of ignition the explosion of the mixture inside the generator took place, raising it, breaking off the pipe connections, pushing the bottom out and igniting the gas mixture in the room.

The four walls of the building were blown outward, showing that the explosion was inside the building, and the puff of flame spread out as far as the gas mixture was combustible.

Had there been any water inside, and had the drain valve been closed, there would have been compressed gases inside the generator and none outside. In this event the explosion would have been more violent, and would have rent the tank; there would have been no soot below the water line, nor in the drain pipe.

It is impossible to attach any blame to the builder of the generator, because somebody left the drain pipe open or somebody opened it. If it had been equipped with a dozen safety valves, such an accident could have happened in the same way. Whether the safety valve, the pressure gage, or other automatic appliances were

properly functioning or not would have made no difference in this case.

I can only call your attention to the fact that acetylene is the most dangerous of all industrial gases. The plant that attempts to generate its own acetylene should be sure that its generation is handled by competent operators who know the properties of endothermic and combustible gases, and by the conditions, whether the automatic appliances are functioning as they should.

A good steam fireman can tell by the looks of his fire whether burning right, but the novice can shovel coal into the fire box and not know whether he is getting the best heat or not, or even wonder why he can't keep up steam when he shovels in more coal, till he fills the fire box. He doesn't know when to fill the boilers with water, nor when to stop. He runs the feed pump because somebody said it was to be run for about one-half hour every so often.

Automatic appliances are necessary if the operator keeps them under the right working conditions.

The cause was either incompetency, carelessness in haste to get away the night before, meddling or ignorant officiousness of somebody.

A Plea For Positive Statements

By Wm. Jay Dana

RECENTLY while looking over an attractively printed booklet gotten out by a large manufacturing plant, I came across a list of "Don'ts." The preceding pages had been pleasant reading. Everything sailed along smoothly and serenely until I struck the "Dont's." Then I felt jostled and bumped and disconcerted. I read them carefully through, however, on purpose to see what impressions I would get.

I had been imagining I was walking through the shops and now was about to start work on a large machine lathe. And there were my written orders which I had just read through: Let me see, was I to wear loose or tight overalls? Did it make any difference whether I cleaned those cone pulleys while in motion? Was I to wear goggles at work or not? If I loaded my work onto the crane myself, was I to hook up the chain tight or loose? I was all at sea. The "Don'ts" had mixed me all up. The Safety First signs had been so reassuring and satisfying and I had felt that ordinary precautions would ensure my being able to do good work in safety. Then I'd read the "Don'ts" and I wasn't sure whether lighted matches were forbidden or merely warned against!

It has always been the same with me ever since the first list of "Don'ts" I saw ten years ago. Why not say "do this now" or, "do this *this* way" or "wear tight or short sleeves," or "when grinding *always* wear goggles?" If Moses had only known a little more psychology, think how much better off the world would be today: A premium awaits the person who will recast the Ten Commandments so that they are all positive commands and all the "Don'ts" are "Do's." Jesus appreciated this when he summed up the Ten Commandments into two positive statements.

Have you noticed that a child is always confused at a negative command? If you want instant obedience you must give definite positive commands. How many drawings have your draftsmen spoiled because you said "Don't put any lines there," when you should have said "Put these lines in here" or "Leave those parts blank" or "Shade *this* section only."

I see now there is an advertisement of famous "Nevers" for draftsmen. If they were only a set of "Always" they would be really worthwhile.

How much better is the mental picture that arises when you say "George, keep the shop clean, please," than when you say "George, don't let the shop get dirty." If you mention the word dirt at all it should be only when you say definitely, "George, clear that dirt out of here *today*" and then add the constructive command for the future "and keep this place *clean* hereafter."

Writers of instructions have found their efforts nullified many a time on account of weak or negative statements when a clear cut concise wording would have eliminated any doubt or hesitation that had arisen.

The military commands are always sharp enough; in fact, they are so positive they make the rank and file jump. It isn't necessary to bawl and bellow to obtain results in industrial management, but all requests or commands should be positively stated.

It is very hard sometimes to find just the right way to explain exactly what one wants done and often takes considerable ingenuity to find the proper phrases. But that's part of the fun of scheming, and the solution of such daily puzzles is the thing that gives true satisfaction. It is the successful overcoming of difficulties that gives the glow that results from having done our best.

Let's revise our Shop Instructions so that there will be no more haze left in the minds of the readers. They must know definitely just how to go about their work in order to do efficiently the constructive work which is required.

U. S. Civil Service Commission announces an examination for student draftsman. Vacancies in the Navy Department, Washington, D. C., and at navy yards and naval stations throughout the United States, for employment during the months of June, July, August, and September, 1921, at $4 a day, and vacancies in positions requiring similar qualifications, at this or higher or lower rates of pay. Applications will be rated as received until Aug. 1. The Navy Department states that appointments under that department from this examination will terminate not later than Oct. 1, 1921; but appointees who are thus dropped will have their names restored to the eligible register for consideration for employment in other branches of the service. Applicants must have completed their sophomore or second year of an engineering course in a college, university, or technical school of recognized standing prior to June 30, 1921. Appointees to positions under the Navy Department will be engaged on either ship or aircraft work, and applicants should state in their applications the class of work to which they prefer to be assigned. Students in naval architecture or aeronautical engineering will be given preference in making appointments under the Navy Department. Applicants must not have oath to the application. Apply for Form 1312.

Coal Dust Hazards in Industrial Plants

A Resume of Conditions to Be Watched to Reduce the Fire Hazard in Plants Using Pulverized Coal. By L. D. Tracy

SINCE the introduction of pulverized coal as a substitute fuel for natural gas in the various types of heating furnaces used in steel mills, a number of fires and explosions have occurred, resulting in the loss of life and property.

There was found to exist among some of those employed about the furnaces in plants inspected a lack of knowledge of the explosive and inflammable qualities of powdered coal.

A small stream of pulverized coal leaking down from a defective joint in a coal transport line did not attract much attention, whereas, had a leak in a natural gas line occurred under similar circumstances, no doubt it would have had immediate attention. As a matter of fact, if by any means the dust cloud should come in contact with an open flame or hot metal, the effects would be as disastrous as if it had been gas.

It would seem desirable, as regards safety, if the management of all industrial plants in which pulverized coal is used for fuel, and especially of those plants in which heating and annealing furnaces are installed, would impress upon their employes the fact that clouds of fine coal dust are as dangerous as a body of unconfined natural gas, if the dust is liberated in close proximity to an open flame or mass of red-hot material.

One of the most serious troubles with which users of pulverized coal have had to contend has been the number of fires in the storage bins for pulverized coal. It has been somewhat difficult to determine the exact cause of these fires, but undoubtedly spontaneous combustion has played an important part in the origin of some of them.

As the amount of heat generated in coal is in proportion to the amount of oxygen absorbed, it is reasonable to assume that if enough air is present pulverized coal when delivered to a storage bin at a fairly high temperature, will in a short time approach the point of ignition.

In some of the systems used in drying and pulverizing coal, the fine coal, about 90 per cent of which will pass through a 100-mesh screen and 70 per cent through a 200-mesh screen, is delivered to the storage bins at a temperature of 125 to 130 deg. F. It is possible, however, for the person running the drier to permit the fire to become hotter than normal and thus overheat the coal in the drier. Such an instance has been brought to the attention of the Bureau. In this case a pyrometer placed in the end of the drier normally registered a temperature of 150 deg. F., but at the time of the explosion in the pulverizing house, a temperature of 350 deg. F. was registered.

Where the drier becomes overheated, the coal may be delivered to the storage bins at a temperature at or above 150 deg. F. If left in the bin for a comparatively short time, it is probable that the temperature of the coal will rise to such a point that when mixed with air the coal will burn rapidly.

Overheating of the coal is especially liable to happen in the type of drier commonly known as "direct heat" drier, in which the gases from the combustion chamber pass directly through the center of the drum and come in contact with the coal passing through. Particularly is this true if for any reason the drier should stop running, while at the same time the fire on the grates is permitted to continue burning.

In connection with these hazards, the following suggestions may not seem out of place. Care should be taken that pulverized coal is not delivered to storage bins at a high temperature; and to avoid this the gases of combustion from the drier furnace should not be allowed to become hot enough to overheat the coal. In "direct heat" driers, the fire should be so maintained that red-hot cinders will not drop into the screw conveyor feeding the pulverizer. The entire safety of the pulverizing plant largely depends upon the man tending the fire in the drier. If he is careless and builds a big fire on the grate, the chances for overheating the coal in the drier are very great. Or, if he should stop the operation of the drier and at the same time maintain a hot fire, hot coal would result, which might be carried into the pulverizer. Such carelessness would probably result in a disastrous explosion.

Storage bins for pulverized coal should not be placed in any position where they may become heated from furnaces, steam pipes or hot flues.

If a plant has been shut down for several days, delivery of coal from the storage bins through transport lines to the place of consumption should not be permitted before an examination is made to ascertain whether the coal has become heated to such a point that it will ignite when brought in contact with a current or blast of air. This can be done by pushing iron rods into the interior of the stored coal and leaving them there for a short time. When they are withdrawn, the temperature of the rods will indicate whether or not there is any fire or overheating in the bin.

Some of the fires that have occurred in the powdered coal distribution lines in several plants have undoubtedly originated from "back fires" from the heating furnaces. These, unquestionably, may be caused by the air pressures in the distribution line suddenly dropping below the secondary air pressures. By secondary air is meant the additional air supply, provided by blowers or otherwise, to furnish sufficient oxygen for proper combustion in the furnaces.

Frequent inspection should be made of the burners and any coked particles thereon should be immediately removed.

In nearly every coal pulverizing plant, there is more or less fine coal dust deposited on the floor, the pulverizing machinery, girders and window sills of the building. If, for any reason, this dust should be raised into a cloud and then come in contact with an open flame, it is probable that an explosion would occur which would wreck the plant. In fact, there was an actual occurrence of this nature in a coal pulverizing plant in which a primary explosion happened in the pulverizer and raised the dust in the building into a cloud, ignited it, and the resulting explosion caused considerable damage to the building, as well as costing loss of life.

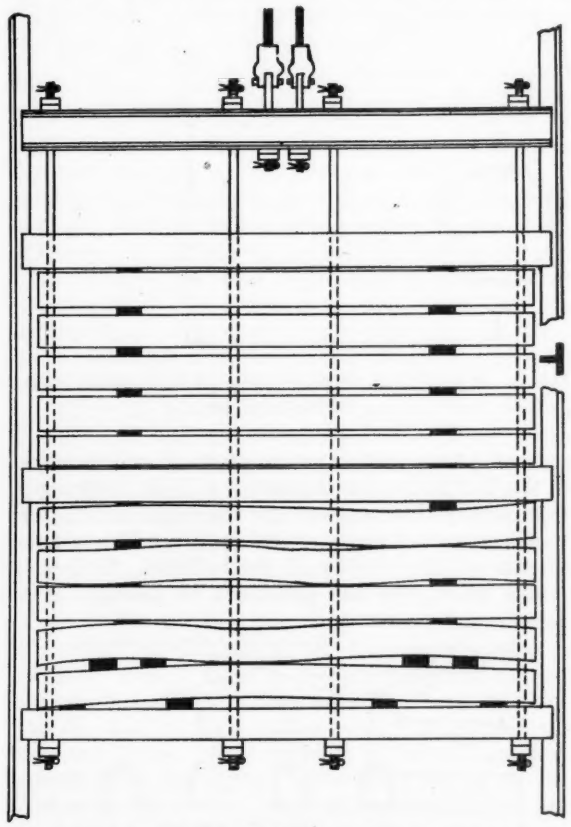
Every effort should be made to prevent any accumulation of dust in the building that houses the pulverizing apparatus. Certain manufacturing plants in which explosive dust is prevalent have installed vacuum cleaners to keep the buildings free from dangerous quantities of explosive dusts.

To obtain the best results, as regards safety, in the use of pulverized coal as a fuel in industrial plants, it is important that both officials and men be educated to the idea that coal dust is explosive and therefore dangerous; and that under certain conditions it will ignite as readily as gas. This fact is not thoroughly understood and sometimes, only at the cost of life and property, is brought home to those connected with the operation.—U. S. Bureau of Mines, Reports of Investigations.

Elevator Weights Break

By George H. Wallace

THE writer has several hydraulic elevators of large capacity and has had some little annoyance with weights in the counterweight breaking at the bolt holes near the middle. As the elevator is slow in movement with no jar or shock, and the counterweight is but



CARDBOARD BLOCKS SUPPORT ELEVATOR WEIGHTS

to balance the weight of the cage and plunger, the cause of the weights breaking was somewhat of a mystery.

The weights are 5 by 6 in. in section and 7½ ft. long, weighing 800 lb. apiece; three, however, top, middle and bottom, being 6 in. longer, extend 3 in. beyond the others at each end in order to engage the "T" iron slides. The weights are held together by two 1-in. rods near the ends and two 1⅛-in. rods near the middle, which pass through a 6-in. channel iron box girder above, to which are attached the cables by suitable lugs as shown in the sketch.

As the broken weights were always near the bottom, it was decided that possibly the weight of those on the top had a crushing effect on those below. It was found also that most of the weights were warped and distorted, which is shown in an exaggerated manner on the lower ones in the sketch. Naturally, the strain would be unequally distributed, and the weights would break at the weakest point, which would be where cored out to receive the middle bolts, although one weight broke halfway between the bolts at the right.

As it is a ticklish job to dismantle the entire weight to renew one or more of the lower ones, I looked around for some means to save this expense. It seemed that the weights ought to be separated by something; and, as heavy cardboard was available, this was cut into 5-in. squares and inserted as shown by black marks, about 18 in. from each end, using as many thicknesses as were necessary to keep the weights from touching. Near the bottom, however, the pieces of cardboard were doubled up and "staggered" as shown further to distribute the weight.

Thin strips of wood, say ¼ or ⅜ in., would serve the purpose equally well or strips of veneer as required. Sheet metal would not be as satisfactory, as it is liable to work out, while cardboard or wood imbeds itself in the metal.

This scheme has been in operation now for quite a while and works very satisfactorily, having already lasted twice as long as it ever did before between breakdowns.

Curiosity

By Claude C. Brown

PAT and Mike, oilers, were very curious to know why it was necessary to leave two valves, the throttle valve and the exhaust valve, open while the engine was running.

Said Pat, "Now, Mike, it's shure a funny thing ye say 'tis the steam that makes her go, an' ye must lave the throttle valve open fer the steam to get to her; now, why do they let it git away by leavin' the exhaust valve wide open as they do? Faith, an' I'm thinkin' they could save a lot o' steam by leavin' it shut!"

"I'll tell ye what we'll do," said Mike, "tonight we'll say nothin' to anyone, an' we'll close the valve an' see what happens."

That night they carried out their plan, Pat standing at the head end of the engine while Mike closed the exhaust valve.

Bang! went the cylinder head; the engine room was filled with steam; the engineer on watch came running over to the engine which had tripped its emergency stop valve.

"What in thunder are you doing, Mike? Where is Pat?" said he.

"Where is Pat?" repeated Mike, as he pulled himself together, "the divil I know where Pat is; but if he comes back as fast as he wint, he won't be gone long!"

Low Pressure Alarm

THE ACCOMPANYING drawing, Fig. 1, illustrates an alarm for low pressure, made by the writer, and connected on the discharge of a service water pump to indicate if the pump stopped or if the pressure dropped from any cause. This pump supplied water to an open feed-water heater, and the cooling coils of the turbines, and it was necessary to keep about 60 lb. pressure on the mains. Referring to the drawing, Fig. 1, diaphragm D is clamped between plate G and washer A in a 1½-in. flange, the lower opening of this flange being connected to pump discharge at H. C is a 1½-in. nipple, capped on top, and carrying adjusting nut I, brass spring E, and fiber piece K K, the fiber pieces carrying contact

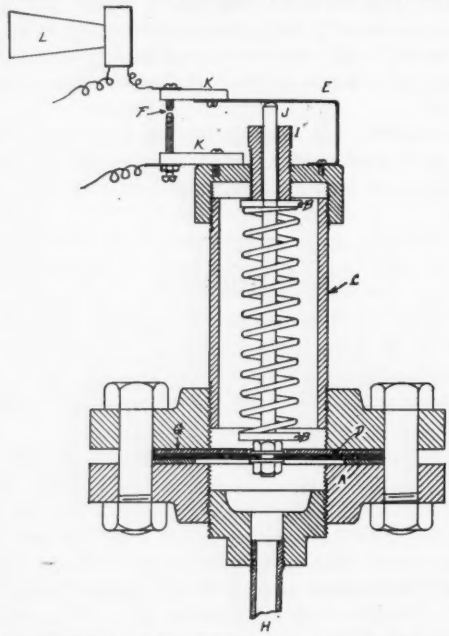


FIG. 1. SECTIONAL VIEW OF DEVICE FOR GIVING WARNING OF LOW PRESSURE

screws F. B B are two washers holding tension spring, the tension on this spring being regulated by nut I. When the pump stops or the pressure drops, the spring forces the diaphragm down, and contact is made at F, ringing the bell or horn, L.

Figure 2 shows a device to indicate on a recording steam gage the time that boiler tubes were blown. B and C connect to soot blowers on each boiler. A is 3-in. connection from steam main. An orifice plate having about a 1⅜-in. hole was placed between flange at E. When tubes were blown, there was a drop of about 25 lb. pressure in the tee which indicated the time on recording gage D.

R. L. MOSSMAN.

Remedy For a Noisy Heating System

LAST SUMMER, we installed a number of new radiators and coils for heating, and also made some changes in the feed and return pipes of our heating system which used live steam. The water of condensation was returned to the boiler by traps.

After the heating system was in service for a time, it was found that there was much noise such as knocking in

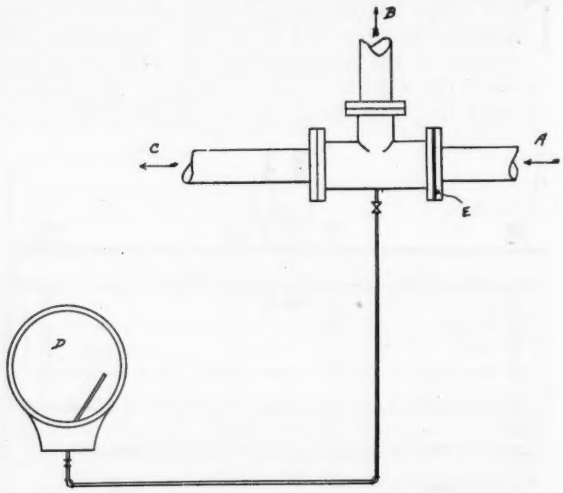
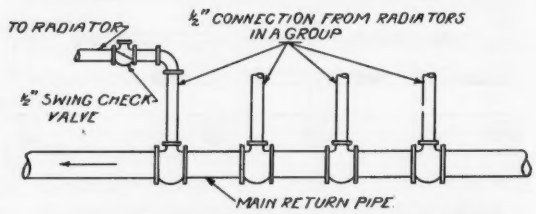


FIG. 2. CONNECTION OF RECORDING GAGE TO SHOW TIME OF DUSTING TUBES

some of the feeders and return pipes. It will be noticed in the illustration that a number of ½-in. return pipes from some of the radiators are connected into the main return pipe in a group which could not be avoided on account of the location of the radiators, feeders and return pipes. As this could not be changed, it was



REMEDY FOR A NOISY HEATING SYSTEM

thought at first that perhaps a larger return pipe would remedy the trouble. This was installed but did not help the matter. Then we thought perhaps more pitch in the main return pipe would help, thinking this would allow the water of condensation to disappear much quicker, hence there would be no opportunity for any knocking

in the pipes. Even with this arrangement, however, we had no better results than before.

In thinking the matter over, I came to the conclusion that most of the knocking was caused by the number of ½-in. return pipes being connected into the main return pipe so close together. This, I reasoned, would allow the condensate and steam from the return pipe of one radiator to back up into the return pipe of another radiator, causing noise when coming in contact with any steam which may have leaked by some of the radiator traps, when discharging the condensate. To prevent this I decided to place swing check valves in each ½-in. line of the radiators, as shown in the illustration. My idea was that, should any of the condensate and steam from one of the radiators have a tendency to back up into any of the other ½-in. lines, the check valve would close and prevent this. After the check valves were connected into the lines, I found that I had made no mistake, as there was no more noise after this.

H. A. JAHNKE.

Operating Difficulties With Generating Units

IN THE April 15 issue is an article, Engine Runaway Narrowly Averted, by Jay See, describing the breaking of the holding rod on the spring of an automatic governor.

The same kind of accident happened to an engine in my charge; only the results and action were different. The engine, which is direct connected to a 250-kw. generator, and runs 200 r.p.m., suddenly speeded up and handled the load at the increased speed without any fuss and the voltage regulator worked all right, but the sound of the machine was wrong, having too high a pitch. The speed indicator was applied and showed 220 r.p.m. The governor is a Rites inertia type, and is more complicated than the drawing accompanying Jay See's article shows. The motors on the line also speeded up as the frequencies increased with the speed, but voltage remained the same as usual.

About the most startling occurrence that ever happened to me was just after I started operating on alternating current machines. I had never been around alternating current machines before, and anybody who has been through the mill can appreciate my state of mind and nerves upon starting up a 250-kw., three-wire, three-phase, 2300-v. alternator and breaking in a new engine besides. I started up the engine and saw that it was O. K. and then chased all the would-be electrical engineers out and locked the doors before going any further. Then I built up the generator and cut in on the line by switching off the outside current and switching the load on the machine. Everything went along fine and I was just beginning to throw bouquets at myself, when the exciter let a squeal out of it like a porker in distress and every instrument on the board tried to kick the high side out of the case with the pointer; also the alternator did some musical stunt. As usual, it was something not down in the books, and time to think was limited.

When building up this machine, the exciter rheostat is turned up until the contact points of voltage regulator drop apart, when a single-pole single-throw switch is thrown in and the rheostate turned back until the regulator starts working. The contact points had stuck together and were firmly welded there and any alternating current man knows what that means, so I grabbed the S. P. S. T. switch, shut both eyes and pulled. The orchestra effect stopped and I regulated by hand until the voltage regulator could be repaired.

OPERATOR.

Noise and Vibration from Electrical Apparatus

VIBRATION and noise in power plants and electrical stations, as pointed out by J. E. Noble, April 1 issue of Power Plant Engineering, may be very troublesome. They may interfere with the operation of apparatus in the plant and may result in litigation for damages to people in proximity. The subject of noise and vibration makes a fitting theme for a book, but a brief review of the subject may help to offer suggestions toward abating certain forms of the trouble in electrical apparatus.

Much noise and vibration can be prevented by proper design of the building and foundations. That this may come about, necessitates close working between the electrical engineer and the architect. Prevention is better than cure, provided that the prevention is not too costly.

As pointed out by Mr. Noble, proper attention to foundations is important. One of the first requirements is for a heavy foundation so that the weight of the foundation is large compared with that of the apparatus supported. With machinery such as synchronous converters of 2000 kw. and above, it is often advisable to isolate the machine foundation from that of the housing structure so that vibration cannot be readily transmitted to the latter. Floors should not make physical contact with foundations; an air gap is the best form of isolation.

The transmission of vibration from machinery to beams and girders is a frequent cause of trouble due to cumulative vibration or so-called resonance. Where isolation is not feasible, flexible contact or absolutely rigid contact with sufficient mass to absorb the vibrations suffices. As the cost increases with the bulk, it is advisable to prevent vibration by the best form of construction rather than by the use of weight alone. In other words, use scientific precautions rather than brute force—mass and weight.

Electrical substations located in residential districts where noise cannot be tolerated are often built with double walls, between which is an air space of dead air which cushions noise and interrupts vibration. It is desirable to prevent circulation of air between the walls, as the current of air would only carry away noise—which is a form of vibration. Dead-air walls cost more than single walls, of course, but the building will require less heating during cold weather and this will help reduce the discrepancy in initial cost.

Much noise can escape from windows, therefore window area and the number of windows should be reduced to the minimum. Noise passing through the roof will be less objectionable to people near the ground outside the station than noise that escapes through windows in the walls. The farther away the windows are from the machinery the better; they should never be located in the direct path of air currents from rotating machinery or due to the draft effect of hot air. In other words, locate the windows in the roof or near the top of the building, if possible.

The above considerations require the attention of the architect. They can be easily done during the time the building is being planned, but would be costly changes if made after the building were completed. The architect can design the building to meet the demand for absence of noise and vibration if he is in close touch with the electrical problem. This means that the electrical engineer and the architect must work closely together.

Quite often, noise and vibration are not of sufficient magnitude to warrant re-designing a building, but are inherent to the apparatus. This is the problem of the electrical engineer; he must solve it.

Vibration and noise may go together; often there is the one or the other. For example, whistling or singing due to windage of rotating electrical apparatus may be a troublesome form of noise. The humming and movement of laminations in the armature or pole pieces with constant or changing flux density is a form of noise and vibration. These troubles can very often be reduced by tightening up moving parts either by turning nuts and bolts or driving in pegs or wedges. Skewed

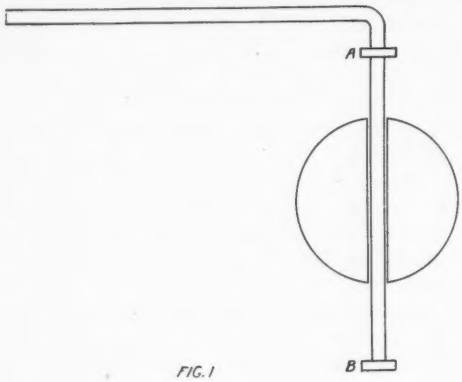


FIG. 1

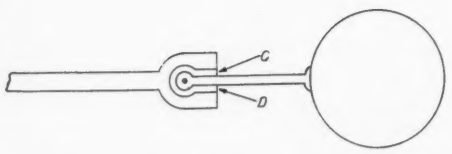


FIG. 2

FIG. 1. TO AVOID FREQUENT STARTING AND STOPPING, THE FLOAT LEVER WAS BENT IN THIS MANNER

FIG. 2. USE OF THE COUNTERSUNK JOINT WILL PROVIDE SAME ACTION AS ARRANGEMENT SHOWN IN FIG. 1.

slots are often used on motors where absence of noise is important.

The electrical manufacturers have done much to do away with rattling parts, windage noises and humming by varying flux densities, modifying pole tips and air gaps. Nevertheless, in some cases it is necessary to encase rotating apparatus where absence of noise is very important. Enclosing apparatus should generally result in increased capacity because of the more efficient ventilation. In some cases this has been very marked after installing a ventilating system or forced draft.

The use of rubber or felt cushions or pads, enclosed rooms with double doors, so-called noise-proof vaults are methods of stopping noise and vibration from induction regulators, transformers, etc. These are minor matters with which the operating engineer in charge can deal.

The writer has known where damages have been sought because of vibration, the plaintiff claiming that bottles and jars were jarred off shelves. Regardless of the truth of this, such a statement serves to show the wisdom of abating vibration and noise before they start. This can be best accomplished by carefully going into the matter with the manufacturer of the apparatus and the architect of the building at the start. A little co-operation at first may save much trouble and expense later.

K. RANKIN.

Improving Float Action

IN A certain building there was a large storage tank, the water feeding through a 4-in. ball cock, and the feed pump was controlled by an electric starter and stopper. Originally the ball was attached to the end of the lever, with the result that the pump was starting and stopping every few minutes. To overcome this, the lever was turned at right angles as shown in Fig. 1. A tube was soldered through the ball and stops were arranged as at A and B. As the water entered above the disc, the weight of the lever above was not enough to open the valve. It required the weight of the ball,

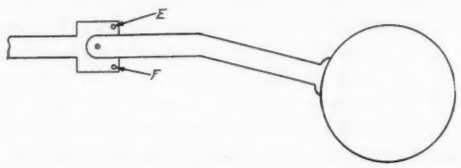


FIG. 3. FOR FLAT LEVERS THIS SCHEME MAY BE USED TO ADVANTAGE

but where the valve was open, it did not close until the lever was lifted up because the water passed the seat or disc. The lever was 30 in. long and the ball 20 in. in diameter. With this arrangement the starter only operated every 3 hr.

The same result could be obtained by using a countersunk joint on the lever, as in Fig. 2, the ball lever coming in contact with points C and D; or with flat levers, the ball lever coming into contact with strong pins or screws, as at E and F. No doubt other arrangements could be made. There was a relief valve on the feed pipe, so that if the starter and stopper failed to operate, no damage would be done.

JAMES ELLETHORN.

Broken Flywheel Discovered by Accident

WE HAVE a 14 by 36-in. engine that runs at 75 r.p.m. It broke the box off the pillow block, four ¼-in. bolts and two ¾-in. dowel pins. We fixed it up and ran night and day for four months.

One day one of the men happened to see a rust spot near the hub of the flywheel. Upon examination, we found all the six arms were cracked. The wheel is 12 ft. 1 in. in diameter, 16-in. face, bolted on shaft in two halves. It is a wonder it did not fly to pieces, but we took it off and put on another. The new wheel is 12 ft. in

diameter, 20-in. face, is twice as heavy as the old one and has eight arms instead of six. The old flywheel was insured and an inspector looked it over the day before our man found the cracks. JOSEPH ENGLISH.

Pump Vs. Trap Feed

ON PAGE 434 of the April 15 issue, Mr. Wakeman seems to think that the exhaust steam is a waste product. Perhaps it is in his plant, but in plants where all the exhaust steam is needed for heating, it is not a waste product, then if you use some of the exhaust steam for feed-water heating you will have to use more live steam in order to make up for the loss of heat that you have taken from the exhaust. By the use of return traps, you are not taking any of the exhaust steam to heat the feed water and you therefore save the live steam used.

Mr. Wakeman speaks of finding a plant in which the exhaust steam for two engines and three pumps was discharged through the roof, while live steam was used for heating the shop. He also says that after remodeling the plant, it showed a saving in fuel, but a return trap was not installed to accomplish this desirable end. There is nothing strange in that statement: anybody knows that with exhausting outdoors valuable heat is going to waste; but it is not a waste product, for it should be used for heating, saving the live steam. After the plant was remodeled, it would show a saving if the returns went to the sewer. He made a saving with a pump and receiver. How much more would be have made if he had put in a vacuum system with another pump or trap?

Mr. Wakeman admits that a trap may discharge at a higher temperature, but says the extra heat is obtained by taking live steam from the top of the boiler and forcing the water into the bottom of the boiler. The principle of trap operation is that as the pressure nearly equalizes in the trap and boiler, the water flows in by gravity.

With a trap none of the condensate loses its heat by coming in contact with the atmosphere. He states that it is the fault of the system if the water in the pump receiver is exposed to air. I have never yet seen one receiver that was not vented to the atmosphere; this seems necessary to prevent binding. I think most engineers are prejudiced against steam return traps for high pressure boilers, but in a few plants I know the engineers claim they are more economical than pumps and easier to care for.

I should consider Mr. Wakeman's boiler a rare case, with not one dollar for repairs in 27 yr.

W. L. N.

I HAVE READ with interest Mr. Wakeman's article in the April 15 number.

No man could write an article, on any engineering subject, that would not be open to criticism by somebody, from some standpoint; to prove it, I will offer a little criticism on Mr. Wakeman's article.

In the first place, the proper place to read the temperature of the returns from a trap feed is before it passes through the trap; and the proper place to read the temperature of pump returns is at a point after it has passed through the pump. The result can be easily imagined; especially where cold water has been used in the vacuum pump suction, which is done in three cases out of four. Therefore, if a plant is using a pump return system, and delivering the water to the boilers at a temperature of 210 deg., and by the use of return traps, it can be returned at a temperature of 220 deg., there is just as much a saving of one per cent as in any other case.

Where does the steam go from Mr. Wakeman's pumps nights and Sundays? Into the heater? Perhaps; but does he pump the returns through this heater? If so, how much of the heat from the exhaust is he able to transmit to the condensate, as compared with the percentage of heat which would be returned to the boiler, if traps were used? He says that it costs no more to send water back to the boiler with a pump than with a trap. I claim that he is entirely wrong; for, in the first place, as I have just stated, there will be a greater loss of heat units from the exhaust of the pump; and there will be several times as much steam consumed by the receiver pump, alone, as with a trap, to handle the same amount of condensate; to say nothing of the vacuum pump consumption.

Why does Mr. Wakeman not ask about the loss of heat from the trap when it releases to the atmosphere, or to whatever point? In the first place, this may be used in a heater during operating hours, or can be discharged into the heating system; but where neither is advisable there is another trick known to return trap men, of returning the relief from the trap to the very receiver from which the water comes, and with very little loss of heat. This is being done very successfully in many plants.

Let us now consider the illustrations. If the system is efficient, and the condensate leaves the coils as soon as the steam condenses, the temperature would be so great that no ordinary pump would handle it, but a trap would. If the factory was of the average type, with many different elevations, and with buildings strewn at all angles, no such layout would work anyway; especially if low-pressure steam was used.

I would like to see the pumping system that will handle the condensate direct from a properly installed heating system, and not give a lot of trouble. Of course, if the coils are too large in proportion to the feeders, and the pressure used, so that the lower ends are heating with water; or if the returns are bare for the whole length of the run, there is a chance that a pump will handle it without its being cooled, but I think a few feet of head would help a lot, then.

Mr. Wakeman does not mention the comparative cost of material and installation of the two systems referred to, to say nothing of the actual difference in the cost of operation and maintenance; but I think if he will get reliable information and compare the two, he will find that there is something to the return trap argument, after all.

I still maintain that the pump system is more expensive, less economical, and to a great extent a hoax, as compared with a properly installed return trap system; and there are a lot of engineers that have found it out, as I have, by a lot of real experience with both.

L. M. REED.

ASKED a chap the other day what he understood by *pep*. He said, "Push—Endless Push."

How to Stabilize the Cost of Power

In April 15, 1921, issue of Power Plant Engineering, appeared an article by L. W. Alwyn-Schmidt on Stability of Cost of Power, the last paragraph of which reads as follows:

"The whole situation calls decidedly for a greater co-operation of power producers upon a local basis. The power engineers have their National and State Association and are a part of the general engineering organizations of our country. In view of the great importance of this branch of engineering and its many local problems, local co-operation should be encouraged by the formation of local professional centers."

This article calls attention to the great desirability of stabilizing the cost of power in any local center, but it has not offered a solution of the problem.

I wish to submit this question and answer: How can the cost of power production for the State of Indiana be stabilized? The answer is this: Generate all power used in the State in super power stations on the Wabash River, in the coal fields, and transmit at high voltage to all points of the State, stepping down to a lower voltage at points where the power would be used.

The main factors in this plan that will tend to stabilize the cost of power produced are as follows:

First—The coal supply. The mines for the coal supply for such a system would be owned and operated by the power generating company, therefore, there would be little change in the cost of coal delivered to the furnace of the boilers from year to year. The cost of transportation of coal would be practically eliminated, due to the close proximity of the mine to the generating station, therefore, a cheap and constant supply of coal.

Second—The volume of current generated. If such a power system required a volume of 100,000,000 kw.-hr. per month, this fact alone would be a wonderful help in controlling the cost of power. In the present power plants, which we would call isolated plants in connection with such a system as now proposed, scattered all over the State and operating under adverse conditions as to the coal and water supply with excessive cost being eliminated, and the power supplied from a greater super generating system, in tremendous volumes, there should be a stability of cost not to be achieved in any other way.

Third—Labor costs. With all power generated in super power station there would be but little change in labor cost from year to year.

Fourth—Supplies cost. Due to the large volume of business and the opportunity to buy in large quantities and under the best conditions, the cost of supplies would be more uniform so that there would be less violent changes in the cost.

Fifth—State control of selling prices, with the power company responsible to the public service commission, who would control the rates, there would be but few changes and any change made would be uniform throughout the State.

All kinds of business needs low, uniform and unchanging prices for power, and fortunate, indeed, is the city, county, district or state that is favored with a supply of power under these conditions, for they would be able to reduce the cost of production on all the commodities of life.

We must also come to the realization of the fact that our fuel supply must be conserved and that when we stabilize the cost of production of power along the lines as suggested in this article, we will at the same time be working toward fuel conservation.

Nothing will stabilize the cost of power production so much as to have the generation and distribution all under one management, subject to State control. The organization of power producers for closer co-operation will be accomplished when the present power plant owners all subscribe for a part of the stock of the power company that would build and operate the super power station and transmission system. Such a system was described and illustrated in March 1, 1921, issue of Power Plant Engineering. Frederick L. Ray.

A Dangerous Habit

Frequently the old careless habit of heating hollow pistons in order to make a shrinking fit with the rod reappears—that is, without first making sure that no water is present in the interior of the piston. Some machinists seem to think that if the water found its way into the piston it will just as easily find its way out again during the heating process. This is where the rub comes in—it may have taken years of slow leakage through some slight porous spot to have filled the interior, whereas the process of heating the piston for a shrinking fit is only one of minutes.

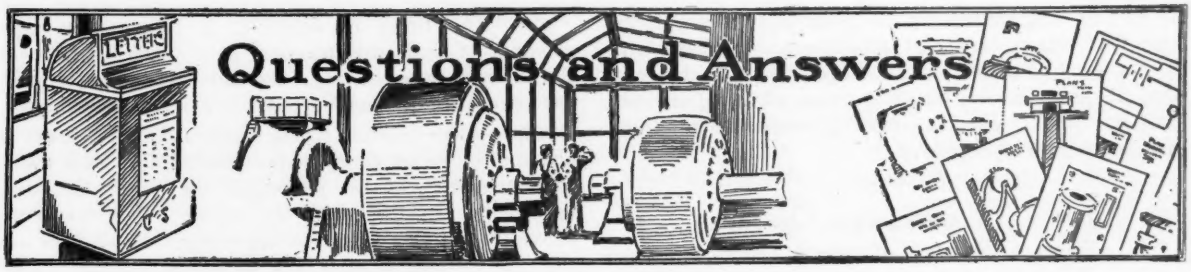
Recently the writer was in the vicinity where an 18-in. piston was being heated. One of the core hole plugs had been removed, and the water drained out. The plug was then made permanently tight. It seems that the moisture left in the piston was sufficient to create a pressure. In any case, the piston exploded with a terrific noise. Some of the pieces were found 500 ft. away, but, fortunately, nobody was hurt.

For this reason it appears necessary when making a shrinking fit with a hollow piston to leave some opening into the interior until after the heating has been completed. John F. Hurst.

Education And Then—

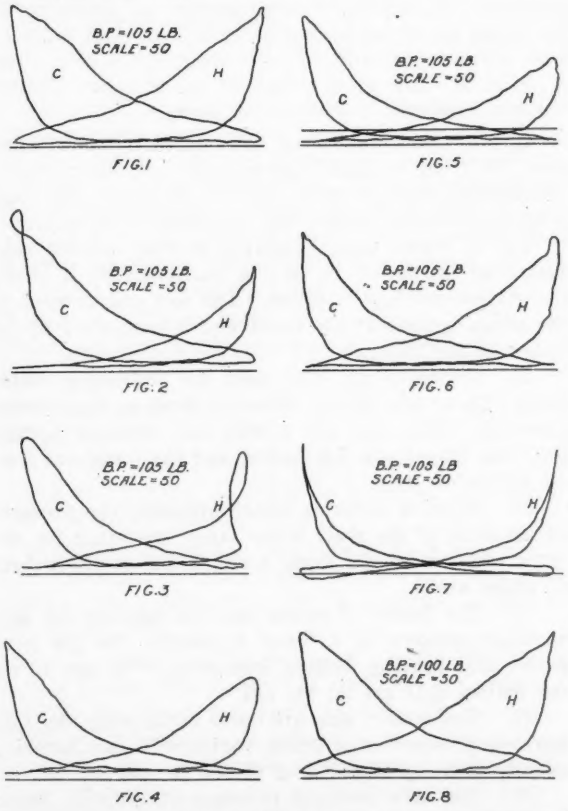
I read an article purporting to originate from an eastern educational institute in which it is stated that "A large proportion of the graduates of the large universities which give electrical courses, when they leave college, enter the laboratories of the large industrial companies and government bureaus. In the management, construction and installation departments of operating companies and manufacturing companies, there is a growing demand for practical electricians, men qualified to take up the task of getting work done."

I was informed by a railroad civil engineer that some of the railroads make a practice of having two lists, one of degree men and the other of correspondence school graduates, and according to the pay and general requirements of the work at hand, the chief engineer would select the next in line and start them in their service. Merit alone counted after that and he observed that there were some correspondence school men shoulder to shoulder with degree men. J. B. Dillon.



What Is The Trouble?

I SUBMIT the accompanying indicator cards for criticism. They are taken from a four-valve Corliss engine with double eccentrics, non-releasing gear, direct-connected to a 250-kw. three-phase generator, with the exciter belt driven by pulley on outboard end of shaft. Cylinder, 20 by 24 in., 204 r.p.m. The engine is equipped with a Rites inertia governor. When the valves are properly set, she runs with less noise than a good many sewing machines.



CARDS TAKEN ON A FOUR-VALVE CORLISS ENGINE

Diagram No. 1 was taken the day before the writer went on an extended leave of absence. No. 2 was taken seven months later with the load on; strange to say, the engine ran smoothly and without noise. The reverse loop on card No. 3 was caused by the pencil hitting the stop and rebounding.

The engine sometimes develops a pound or a knock, whichever you please to call it. No. 4 is a card taken at a time when the engine was pounding and No. 5, strange to say, is a card taken when the pound had disappeared.

After setting the valves, No. 6 was obtained. No. 7 is a friction card and No. 8 is an old card, taken long before any of the others. I would particularly appreciate criticism of cards No. 6, 7 and 8.

I do not claim to be a card (indicator) sharp and it sometimes takes me considerable time to make up my mind before making any changes. I have found that it does not pay to be in too great a hurry, especially with an engine of this kind. The most difficult thing for me is to make the compression equal.

The boilers at this plant are fitted with underfeed stokers and the coal we use is of a poor grade, yet, I am having unusual difficulty in carrying the load on the boilers. Theoretically, the load has never been so large but that one boiler should be able to carry it. I have experimented, but was never able to hold the load for over an hour, although the fires were clean and white hot; CO_2 14 per cent and the settings tight and covered with a coating of air sealing compound. What I would like to know is, how do some engineers manage to obtain 200 to 300 per cent rating out of a boiler? I have been in a plant and watched a boiler, rated at 485 hp., deliver 1100 b.hp. according to the indication on the steam flow meter.

I can obtain equally hot fires, the same per cent of CO_2 but can obtain only just so much out of my old 72-in. by 18-ft. horizontal tubular boilers. Even with two boilers on the line, this difficulty occurs. This afternoon, for instance, after the noon coal delivery, I had everything in good shape and started off fine. By 3:30 p.m., however, there was only 55 lb. pressure on the boilers and it became necessary to shut down the engine.

If I had a fireman, I might be able to blame him; but as I do my own firing, I happen to be the goat. I would appreciate having some of the readers comment on this. OPERATOR.

Cleaning Electrical Apparatus

WE OPERATE a 25-hp. electric motor upon which some dust will settle and probably get into some of the working parts. A live steam connection is very convenient to our motor, and we would be very much interested to know if any harm would result if we occasionally turned some live steam upon all parts of the motor for cleaning purposes. H. D. R.

A. Under no circumstances would we recommend the use of a steam jet for the purpose of removing the dust from any kind of electrical apparatus. As soon as the steam would impinge upon the comparatively cool surfaces of the motor structure, it would immediately be condensed and the water would find its way into and between the windings, and as a result the machine would undoubtedly not only cause you much trouble in the way of irregular operation, but probably would burn out.

If you find it necessary to clean your machine, the only two courses for such procedure are the following: Either provide some form of compressed air supply so that this may be used for the purpose of dislodging any dust or dirt, or else dismantle the entire machine and clean each part separately.

Engineer's Examination Questions*

17. What is the result of scale in boilers and why?

18. What would be the best thing to do if you found that large amounts of scale were forming in boilers under your care?

19. What injury would foaming produce, and what would you do?

20. What is a safety-valve. (a) On what general principle is it constructed?

21. What determines the proper size of safety valve for different size boilers?

22. Does the steam gage register absolute pressure?

23. What is a water gage, and how is it actually analyzed?

24. What other devices are used for indicating water levels?

25. When a boiler is under steam, is the pressure on all sides of the boiler the same?

26. What factor is generally used in figuring the safe working pressure of boilers?

27. What value of tensile strength would be used in the rule for safe working pressure of boilers?

28. What is the safe working pressure of a boiler 66 in. in diameter, tensile strength, 58,000 lb. per sq. in., longitudinal seam double riveted lap joint, shell 11/16 in. thick, factor of safety 5?

29. What relation should the rivet hole be to the thickness of the plate?

30. Single riveted joint 3/8-in. plate, give diameter of rivet hole, and pitch of rivets, distance between edge of plate and edge of hole.

31. At what pressure will a safety-valve having a diameter of 4 in. blow off when the weight of the valve and stem is 10 lb., of the lever 20 lb., of the ball 120 lb.? The total length of lever is 44 in., the weight is 40 in. from the fulcrum and the distance from the center line of the valve to the fulcrum is 4 in.

32. Boiler 72 in. diameter, 16 ft. long, with 60 tubes 4 in. in diameter, longitudinal joint double-riveted, rivet holes 5/8 in. in diameter, pitch of rivets 3 in., tensile strength 60,000 lb., shell 1/2 in., heads 1/2 in., distance from shell to top of tubes 24 in., factor of safety 5. Give safe working pressure and horsepower, and number of braces for each head, allowing 4000 lb. on each brace.

33. Give size of pump, steam and water end, and piston speed in feet per minute, for question No. 32.

34. What is the horsepower of an engine having a cylinder 18 in. in diameter, stroke 30 in., mean effective pressure 40 lb., revolutions per minute 120?

35. What is the safe maximum speed of a flywheel?

Answers

Scale formation on the boiler results directly in reduction in efficiency of heat absorption because the insulating properties of this scale are much greater than that of iron.

Continued from page 487, May 1 issue.

18. The thing to do if it is found that large amounts of scale are forming in a boiler is to treat the water to remove these elements and make frequent use of a tube cleaner.

19. When a boiler foams badly, it carries excessive amounts of water along in the steam line. This water will accumulate in the pockets of the piping and will, eventually, be blown into the engine unless traps are provided. If this gets into the engine, the chances are that the cylinder head will be blown off and the engine wrecked. Foaming is frequently caused by restricted evaporation surface, or foreign material in the feed water.

20. A safety valve is a valve that opens the boiler to atmospheric pressure when the internal pressure exceeds a certain given amount. It is, essentially, simply a poppet valve kept down in its seat by either a spring or a weight.

21. The size of a safety valve depends on the pressure at which it is supposed to blow and also upon the weight of coal burned per square foot of grate surface per hour. It should be large enough to discharge all the steam generated by the boiler at maximum capacity with a rise in pressure of only about 6 per cent. The A. S. M. E. Code gives a table of safety valve sizes for various pressures and rates of firing.

22. A steam gage does not register absolute pressure, but what is called gage pressure or pressure above atmosphere, which is about 14.7 lb. per sq. in. less than absolute pressure, where the barometer is standard.

23. A water gage is simply a glass column connected to the boiler in such a position that it shows the water-level in the boiler. The top end is open to the steam space and the lower end is connected to the water in the boiler.

24. Try-cocks are also used for indicating water level. There are usually three of them so located one above the other that the middle one indicates normal level, the upper one full boiler, and the lower one lowest allowable level.

25. When a boiler is under pressure, the pressure on all sides of the shell is the same, excepting for the extra pressure in the lower sections due to the weight of water above.

26. The factor of safety used in figuring the safe working pressure of a boiler is usually five for new, power and heating, boilers, increasing with age to six for boilers that are 25 yr. old.

27. The tensile strength used in figuring the safe working pressure of a boiler varies with the material, usually between 55,000 and 65,000 lb. per sq. in.

28. The safe working pressure of a 66-in. boiler having a tensile strength of 58,000 lb. per sq. in. and an assumed joint efficiency of 75 per cent, is 181 lb. per sq. in., the shell being 11/16 in. thick and the factor of safety 5, as you say. The equation used in making this calculation is $p = 2t$ T. S. E. $\div$ D, where p = allowable pressure, t = plate thickness, T. S. = allowable tensile strength of material, E = joint efficiency, and D = diameter of shell.

29. The relation of the diameter of a rivet hole to the thickness of the plate for riveted joints can be expressed by the equation: $d = 1.5 \times \sqrt{t} - 3/16$ in.

30. For a single riveted joint of 3/8-in. plate the diameter of the rivet hole should be 3/4 in. and the pitch

2¼ in.; the distance between the edge of the plate and the edge of the hole should be equal to ¾ in.

31. A safety valve having a diameter of 4 in. and weighing 10 lb., connected to a lever 4 in. from the fulcrum, the weight of the lever being 20 lb., its center of gravity 22 in. from the fulcrum with a counter-weight of 120 lb. 40 in. from the fulcrum, will blow at a pressure of 105 lb. gage.

$$p \times 0.7854 \times 16 \times 4 = 4.10 + 22 \times 20 + 40 \times 120$$
$$p = 105$$

32. For a boiler 72 in. in diameter, 16 ft. long, having 60 tubes 4 in. in diameter, longitudinal joints double riveted, rivet holes ⅝ in. in diameter, pitch of rivets 3 in., tensile strength 60,000 lb., shell and head ½ in. thick, distance from shell to top of tubes 24 in., factor of safety 5: the efficiency of the joint in tension is:

$$E_t = (p - d) \div p = (2\tfrac{3}{8}) \div 3 = 0.79$$

Efficiency in shear,

$E_s = (1.8 \times 3.14 \times d^2 \times U_s) \div (2 \times p \times t \times U_t) = (1.8 \times 3.14 \times (\tfrac{5}{8})^2 \times 45{,}000) \div (2 \times 3 \times \tfrac{1}{2} \times 60{,}000) = 0.55.$

Efficiency in compression,

$E_c = (2 \times \tfrac{5}{8} \times 80{,}000) \div (\tfrac{1}{2} \times p \times 60{,}000) = 0.60.$

The lowest efficiency, of course, prevails so that the tensile strength is 55 per cent of 112,000 lb. = 6600 lb. and the pressure allowable is equal to $2 \times \tfrac{1}{2} \times 6600 \div 72 = 91.8$ lb. to the square inch. The rated horsepower may be figured from the normal rating of 12 sq. ft. per hp. The area of the heating surface is composed of that of the tubes and of the shell and is equal to:

$60 \times 3.14 \times 4 \div 12 \times 16 + \tfrac{1}{2} \times 3.14 \times 72 \div 12 \times 16 = 1155$ sq. ft. which corresponds to 96½ hp. The area of head to be supported by braces is $A = 4/3 \times (24 - d - 2)^2 \times \sqrt{[2} \times (36 - d) \div (24 - d - 2) - 0.608]$ in which $d = 5 \times T \div \sqrt{p} = 5 \times 8 \div \sqrt{92} = 4.17$ in.

T = thickness of head in 16ths of an inch.

The area is then, $A = 4/3 \times 17.83^2 \times \sqrt{(63.66 \div 17.83 - 0.608)} = 895$ sq. in.

The total force on the end of the boiler is then $895 \times 92 = 82{,}500$ lb., and the number of stays necessary, each having a tensile strength of 4000 lb., is $82{,}500 \div 4000 = 20.6$, or, say, 21.

33. To determine the size pump for the feed water for this boiler: The boiler will need $34\tfrac{1}{2} \times 96\tfrac{1}{2} = 3300$ lb. of water per hour or 55½ lb. per min. or 0.91 cu. ft. per min.; it is usually best to allow twice this amount for safety's sake, which would make it 1.82 cu. ft. per minute; it is also customary to allow 20 per cent additional pressure for piping, etc., which would amount to a total of 110 lb.; figuring 50 strokes per minute, the pump will deliver $1.82 \div 150 = 0.0121$ cu. ft. per min. or 21 cu. in.; allowing 20 per cent for slip, this becomes 25.2 cu. in.; assuming the length of the stroke equal to twice the diameter, the volume of the cylinder is equal to $0.7854 \times d \times 2d$, from which d is equal to the cube root of $25.2 \div 1.57 = 2\tfrac{1}{2}$ in. approximately; the pressure pumped against is 110 lb. and the steam pressure available at the pump is 73½ lb. so that the diameter of the steam piston is $110 \div 73.5$ times the diameter of the water piston which equals 3.75 in. L is twice the diameter or 6½ in.

34. The horsepower of an engine can be figured from the equation:

$$\text{hp.} = P\,L\,A\,N \div 33{,}000$$

where P is the mean effective pressure, L is the length of stroke in feet, A is the area of the piston in square inches, and N is the number of working strokes per minute. Substituting these values in this equation we get:

$\text{hp.} = 40 \times 30 \div 12 \times 0.7854 \times 18^2 \times 120 \times 2 \div 33{,}000 = 185$ hp.

35. The safe maximum speed of a flywheel depends upon the material from which it is constructed. For cast-iron wheels, 100 ft. per min. is usually considered the maximum safe speed.

Specific Heat of Saturated Steam

WHAT IS MEANT by the term "specific heat of saturated steam"? R. B.

A. The expression (specific heat of saturated steam) is somewhat of a misnomer, and the term is not generally used or appreciated. When speaking of heat added to or subtracted from saturated steam, we consider the quality, latent heat and heat of the liquid at the pressure and temperature given. If you consider the specific heat of saturated steam, the amount of heat required to raise the temperature of one degree and still maintain it in a saturated condition, the heat will have to be subtracted instead of added. In other words, the specific heat will be negative and can be found from the equation:

$$C = 0.35 - 0.000{,}666\,(t - 212) - (r \div T)$$

where C is the specific heat, t the temperature of the steam, and $r \div T$, the entropy, where r is the latent heat of evaporation, and T is the absolute temperature.

For steam at atmospheric pressure, this would give a specific heat of —1.0947.

This specific heat is considered at constant pressure and is consequently purely hypothetical because in order to raise the temperature and still maintain saturation, the temperature would necessarily have to be raised.

We would discourage the use of this term, as it is likely to be misleading.

Fans for Air and CO_2 Gas

IF TWO fans of the same size are running at the same speed, one working on air, the other on carbide dioxide gas, the pressure and temperatures at the intake being the same, which fan would produce the greater pressure and why? V. N.

A. Two fans of the same size and construction operating one on air and the other on carbon dioxide gas at the same pressure and temperature would deliver these gases at a pressure proportionate to their densities. Thus the ratio of the pressure produced on the carbon dioxide to that produced on the air is as 1.5291 is to 1. The horsepower required to do this work would be in the ratio of $\frac{3}{2}$ power of the gas densities. In other words, the fan handling the carbon dioxide would require 1.8908 × the horsepower required for handling air.

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Establishing an Operating Standard

Even today the remark is frequently made that power plant records cost more to keep them up than is saved by their use. Probably this is the truth to those who do not know how to use these records, but there is no excuse for such ignorance in these days. Yet all the uses to which records of operating data may profitably be put are not general practice even in the most up-to-date plants of the country, and there are undoubtedly many ways in which records may be used which have not as yet been discovered. By the development of many different kinds of graphic recording instruments, the past few years has seen record systems grow considerably in favor, as these instruments relieve the attendants of the great amount of detail work of recording periodically the readings of indicating instruments.

The continuous test has for many years been the principle of record keeping in plants where highest efficiency is obtained and the results obtained in daily operation are compared with those secured during a special test run under as nearly ideal conditions as possible. Undoubtedly this has its value; but those in charge of operation justly criticise this comparison, as the load conditions are practically out of their control and the load condition has a direct influence on the efficiency.

It was to overcome this criticism of the method of comparing operating and test results that the method described by Mr. Delany in a paper read at a meeting of the San Francisco section of the American Society of Mechanical Engineers, and reproduced on other pages of this issue, was devised and put into practical operation. The principle involved in this comparison is not new, being an adaptation of Willans lines to actual everyday operation with the standard lines established by past records.

The basis of comparison is the fuel used per kilowatt-hour developed over a period of a day or a shift. This pitting of one shift against another, or the results of the same force one day against its record another day, undoubtedly has its beneficial results in bringing up the efficiency of a plant and keeping those in charge keyed to the highest pitch. One of the great difficulties which has always existed, and still does to a great extent, is the fact that exact knowledge of the results obtained lags behind operation, a day, a week or a month, so that corrective measures for bad conditions may not be started until some time after these conditions have been wasting fuel, due to the lack of knowledge of their existence.

Every step such as Mr. Delany has taken is an aid in this direction, and it is hoped that before long some means will be provided by which those in charge will know continuously just what results they are securing.

Industrial Distribution Systems

The rapidly increasing use of electricity in industrial plants has made it necessary for electrical engineers to give more attention to the design of electrical distribution systems in such plants. A number of years ago, when a few large motors driving long systems of line shafting, together with the lighting system comprised the entire electrical layout, the matter of designing the distribution system was comparatively a simple proposition. In fact, there was little of what might be termed,

design, to it. As these plants grew in size and as the use of electricity became more common and as the advantages of individual motor drives became to be appreciated, the distribution systems also underwent expansion. Such expansion often resulted in piecemeal distribution systems, intricate in detail, and installed without further consideration than to connect to load to the generator. New apparatus was often installed and connected to the system without properly considering the capacity of the original feeder system.

Today, the problem of designing distribution systems for industrial plants is one of no small importance, and the correct solution is dependent upon a number of variable factors. While each case, as a rule, must be treated individually according to the class of service intended, there are nevertheless, a number of underlying principles which can be considered as applying to practically all conditions. In the pages of this issue V. E. Johnson discusses fully these principles together with various types of systems in use.

One of the first points to be decided upon when contemplating a new distribution system, is that of voltage. What is the best voltage for any given plant? This question cannot be answered without taking into consideration the size of the system, the type of apparatus used, type of system desired, etc. Mr. Johnson takes up each of these points individually and weighs them carefully against each other in the process of arriving at the best possible solution of the problem.

A distribution system, like a chain, is no stronger than its weakest link and an electrical system is no stronger than its distribution system. Continuity of service is probably the most important feature to be desired. It is the task of the distribution engineer to make every link in the distribution system as strong as possible in order to avoid expensive shutdowns and, at the same time, to secure the highest operating efficiency attainable.

Off Duty

It may have been notice that in these Off-Duty talks we frequently discuss either the exceedingly small or the enormously large. We admit that there is a fascination about these subjects which we cannot resist. They show, as nothing else will, the wonderful power of the human mind in devising methods for doing the seemingly impossible.

Some time ago, you will probably remember, we discussed a new method of measurement—a method by which we could accurately measure down to the two-hundred millionth part of an inch. Well, today we are going to talk about a method of weighing small quantities, so gather around the Off Duty table while we proceed.

We are all more or less familiar with various forms of weighing apparatus, and are reasonably conversant with their principles of operation. In our daily work we have occasion to use anything from a simple spring balance to an automatic, recording, weighing hopper, such as the fireman uses to weigh the coal he delivers to his stoker hoppers. The latter is, without doubt, a highly ingenious device, and from that standpoint interesting, but we have to do with much smaller masses than either of the above-mentioned scales are capable of weighing, hence we can discard them from our consideration.

The laboratory balance, which the chemist employs, while not so conspicuous nor intricate as the automatic weighing hopper referred to above, is nevertheless far more sensitive. It is capable of weighing exceedingly small objects with greater precision than the weighing hopper can weigh a ton of coal. The art of making such balances is not new, for even as much as 50 yr. ago it was possible to construct a balance so sensitive that one could weigh a piece of paper, then write his name with a hard pencil on the paper and determine the difference between the new weight and the old. In other words, it was possible to weigh the name. This meant determining a weight as small as one-tenth or one-hundredth of a milligram and a milligram is about 1/30,000 of an ounce.

About 12 yr. ago Ramsay and Spencer, in London, by constructing a balance entirely out of fine quartz fibers and placing it in a vacuum, succeeded in weighing objects as small as one-millionth of a milligram—one-thirty billionth of an ounce! This was, indeed, a marvelous degree of sensitiveness, but even this has been exceeded.

When Prof. Robert A. Millikan was performing his world-renowned researches at the University of Chicago on the value of the ultimate electric charge, that is, the value of the charge on the electron, it became necessary in the course of his experiments to weigh accurately some microscopically minute drops of oil, which he floated in the air space between two electrically charged condenser plates. These drops were so small that some of them could only be seen through a microscope. Yet, with the balance he employed he was able to weigh them accurately and easily to the one ten-billionth part of a milligram—the one-hundred trillionth part of an ounce!

Just how this was accomplished is, of course, a long story—too long for us to go into details. We can, however, explain the principle involved.

Imagine, a small oil drop, such as referred to above, floating in the air space between two condenser plates. Such a drop can be rendered visible by reflected light in an ultra microscope. Now, by means of radium or X-rays such a drop can be electrically charged, and by Prof. Millikan's method, the charge so applied can be accurately measured. This being done, it is then merely a matter of varying the potential applied to the plates or the charge on the drop until its weight is just balanced by the upward pull of the electric field. The weight of the drop is then exactly equal to the product of the known charge by the strength of the electric field.

It will thus be seen that this device is simply an electrical balance in place of a mechanical one, but it weighs accurately to the one-ten billionth part of a milligram.

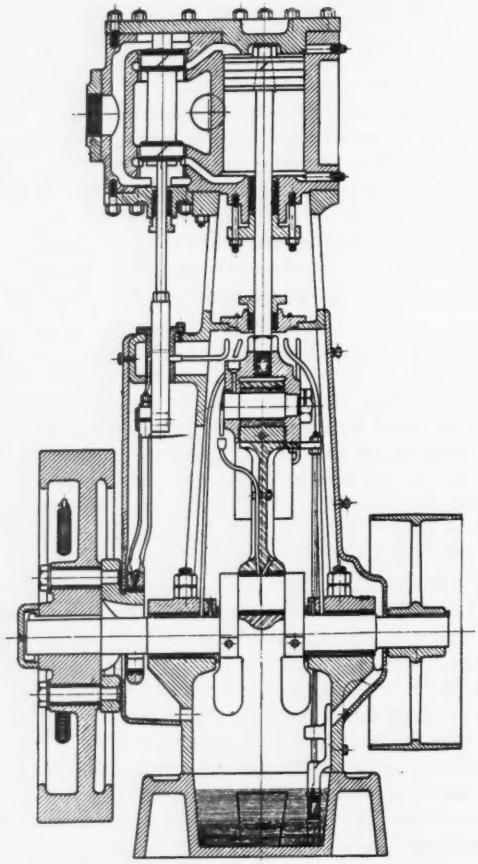
Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Compact Auxiliary Engine

DESIGNED especially to serve such auxiliary equipment as automatic stokers, compressors, pumps, fans, mixers, driers, as well as refrigerating machines and small generating sets, is a compact vertical steam engine manufactured in sizes from one to 100 hp. which we find on the market.

This machine is the result of years of careful design and construction coupled with experiments and observations of actual conditions of operation, consequently the design embodies sound modern engineering principles. Emphasis is laid on the simplicity and compactness of design, the dependability and economy in both



TYPICAL VERTICAL SECTION OF A COMPACT VERTICAL STEAM ENGINE FOR AUXILIARY AND SMALL POWER PURPOSES

steam and oil, low cost of maintenance, and also on the fact that freak ideas or pet hobbies have not been allowed to enter into the construction.

All unnecessary complications have been eliminated, but nothing has been sacrificed that would contribute to successful performance. Accessibility is another feature claimed. Removable side doors are provided on both sides of the engine frame allowing access to the crosshead, wristpin, connecting rod, crank and all adjacent parts.

Reference to the accompanying illustration will furnish a general idea of the construction of a typical engine.

The piston is made of selected material and is designed to give maximum strength with minimum weight, it is taper fitted to the piston rod. Both members are accurately ground to minimize steam leakage. The connecting rod is substantial and rather short, about 4½ times the crank length and is of drop forged construction in the smaller sizes and cast steel in the larger. The bearings are of ample proportions and are provided with take-up adjustment. The crosshead is made with phosphor-bronze shoes and is provided with a wedge adjustment to compensate for wear. The crankshaft is of forged steel fitted with counter-balances and is accurately ground to size.

The valve is of the balanced piston type ground to a sliding fit in the valve chamber. It is furnished both with and without snap rings. The valve chamber is fitted with a removable bushing which takes the wear and may be replaced when necessary. Reboring of this chamber is thus unnecessary.

Lower speed type engines are governed by a throttle governor while those of the higher speed class are controlled by an automatic shaft, combination inertia and centrifugal governor that actuates the eccentric. The flywheel is of large diameter and of sufficient weight to insure smooth running.

Lubrication is accomplished by a pressure system. An oil pump in the sump supplies oil under pressure to a reservoir on the frame of the engine from which it is distributed to all bearings and rubbing surfaces. A water shed partition is fitted between the cylinder and crosshead to prevent oil from coming in contact with the hot cylinder head.

These engines are made in sizes from 2½ by 3½ in. to 15 by 10 in. corresponding to a capacity range from one to 100 hp. at approximately ¼ cutoff; to a speed range up to 750 r.p.m. on the smaller sizes and 350 r.p.m. on the larger; and to a range in throttle pressure of from 20 to 200 lb. gage.

Permanent Exhibition of Machinery and Mechanical Appliances

THE Manufacturers Exhibition Company has taken a long-term lease on two floors and basement of the Greenhut- Siegel-Cooper building, New York, for a permanent exhibition of machinery and mechanical appliances.

This places over 200,000 sq. ft. of floor space in a centrally located building at the command of manufacturers who desire a permanent show- and sales-room in New York, with every business office facility as well, and with ample storage space in the basement available for carrying stocks for immediate delivery. Machinery may be shown under power if desired.

L. R. Duffield, organizer of the Manufacturers Exhibition Company, and its president and general manager, is widely and most favorably known among machinery manufacturers throughout the country, and his long experience in this line, together with ability and a pleasing personality are sure to be large factors in the success of the business.

Mr. Duffield was general manager of the exhibition department of the Philadelphia Bourse for 10½ yr. and has been general manager of the International Exposition of Industries, Grand Central Palace, New York, which building, according to recent newspaper announce-

ments, has changed ownership and is to be converted into an office building.

News Notes

CHARLES H. MACDOWELL was elected president of the Western Society of Engineers at the election held May 4. Mr. MacDowell is president of the Armour Fertilizer Works and brings to this position a wide experience as an executive. The other officers elected are: First vice-president, Julius L. Hecht, assistant to vice-president Public Service Co. of Northern Illinois; 2nd vice-president, F. F. Fowle, consulting electrical and mechanical engineer; 3rd vice-president, Benjamin B. Shapiro, consulting structural engineer; treasurer, Homer E. Niesz, manager of industrial relations, Commonwealth Edison Co.; trustee, Edwin W. Allen, assistant district manager and district engineer, General Electric Co.; members of Washington Award Commission: John F. Hayford, director school of engineering, Northwestern University, and Henry J. Burt, manager Holabird & Roche. The officers-elect will take office on the first Wednesday in June.

SINCE THE announcement was made in the May 1 issue relative to the moving of the offices of the L. J. Wing Mfg. Co., the company has decided to retain its general executive and sales departments at the old address in New York City. The factory, however, has been moved, as previously announced, to Newark, N. J.

THE POWER SPECIALTY CO. has opened additional offices in Kansas City, Mo., 512 Reliance building, and Dallas, Texas, 627 Linz building. The Kansas City office is in charge of William F. Meyer, who has been with the Power Specialty Co. a great many years and who for the last 2 yr. has been attached to the Chicago sales office. The Dallas office is in charge of M. W. Brown.

W. H. GAYLORD, JR., formerly president of the Gaylord International Engineering Construction and later sales manager of the McPhee Cement Co., has joined the Quigley Furnace Specialties Co., as assistant traveling sales manager in charge of the establishment of agencies for Quigley products and will make his headquarters in New York.

AT THE annual meeting of The Burt Mfg. Co., held on May 2, J. Asa Palmer, who has been general manager of the company for a great many years, was elected president and general manager, taking the place of W. F. Warden, who died in Florida last January, and who had been president of the company almost from its inception.

HOMER J. FORSYTHE, manager of the construction division of the engineering department of the Du Pont Co., has been transferred to the position of assistant general manager of the Hyatt Roller Bearing Co., of Newark, N. J., a subsidiary of the General Motors Corporation.

THE CHICAGO BRANCH Store of the Lunkenheimer Co. moved, May 1, from 188 No. Dearborn St. to 568 W. Washington Blvd.

THE MCCLAVE-BROOKS CO., Scranton, Pa., has moved its New York Office from 50 Church St. to Printing Crafts building, 461 8th Ave.

C. H. WHEELER MFG. CO., of Philadelphia, has removed its New York office from 114 Liberty St. to 50 Church St.

THE NEW YORK offices of the Chicago Fuse Mfg. Co. have been removed to the Tilden building, 105 W. 40th St.

GIAVER AND DINKELBERG, engineers and architects, announce the removal of their offices, May 1, to 500-504 Wrigley building, Chicago, Ill.

THE ELLIS DRIER CO. has moved its Chicago offices from 336 So. La Salle St. to Roosevelt Road and Talman Ave.

COMBUSTION ENGINEERING CORPORATION has recently established offices in its own building which has just been completed and will be known as Combustion Engineering Building, on Broad St., New York City.

THE AMERICAN ENGINEERING CO. announces the appointment of Isaac Hardeman as sales agent in the states of North Carolina, South Carolina and Georgia. His office is located at 816 Realty building, Charlotte, N. C.

THE CHICAGO OFFICE of the Uehling Instrument Co., of New York, was moved, May 1 to the Great Northern building, 20 W. Jackson Blvd. Walter C. Lange has been appointed manager of this office.

ADOLPH SORGE, JR., died May 5. Mr. Sorge was a graduate of the Stevens Institute of Technology, at Hoboken, N. J., of the class of 1875. Shortly after leaving school he went with the E. W. Bliss Co., of Brooklyn, and had charge of their exhibit at the Centennial Exposition at Philadelphia in 1876. About the year 1893 he became general manager of the Wood-Mosaic Co., of Rochester, N. Y., and was largely responsible for developments that occurred in the manufacture of prepared wood-mosaic and parquetry flooring, including the cutting of wood in blocks so that the end of the grain, instead of the side, is exposed to wear. Mr. Sorge was a clear and analytical thinker, as well as a capable and ingenious engineer, and had the capacity of becoming expert in many different lines. While in Rochester he acted as advisor to Selden in framing the claims of the famous automobile patent subsequently issued to the latter.

From Rochester Mr. Sorge went to Chicago, becoming superintendent of the foundries of the Fraser-Chalmers Co., building mining machinery and steam engines. In 1895, he resigned to become the general western representative of the Harrison Safety Boiler Works, of Philadelphia, subsequently incorporated as the H. S. B. W.-Cochrane Corporation, and established branch offices in St. Louis, Detroit, Indianapolis, Cincinnati, Minneapolis and Omaha. He was the first to see the advantages of heat in the chemical treatment of water for the removal of hardness, and the present Sorge-Cochrane hot process water softener is a further development of ideas originally patented by him. He was often consulted on steam plant problems and his skill in rectifying defective steam plant piping was widely known throughout the West. He was one of the originators and founders of the Technical Club of Chicago and was also a member of the Engineers' Clubs of Chicago and New York, as well as of the American Society of Mechanical Engineers. His home was in St. Joseph. Mich., where he gratified his love for country life and things agricultural. His wife survives him.

ADVICES from Wyoming are that on April 21 Denny Brothers, owners of the Rock River, Wyo., electric plant, shut down the plant, leaving the town in darkness. The proprietors claim that they have been operating at a loss for some time. Nearly two months ago, they notified the city that they would cease operation, March 20, but extended time one month on the plea of city officials. The city was offered the plant for $12,500 if it would buy within a certain time. This it failed to do, so the price was increased to $17,500.

THE GROSS earnings of the Westinghouse Electric & Mfg. Co. from sales billed for the year ending March 31, 1921, were, as shown by the company's annual report, $150,980,000, which is an increase of $15,000,000 over the gross earnings of the previous year. The manufacturing and selling cost was $138,774,000; and the net income available for dividends was $12,618,000, or 16.8 per cent on the company's capital stock. Dividends at the rate of 8 per cent per annum were paid during the year on both the preferred and common shares of stock.

There is included in the cost, $5,315,000 for depreciation and adjustment of inventories, which were valued as of Dec. 31, 1920, at cost or market value, whichever was lower. An appropriation of $5,000,000 from surplus for a special contingent reserve has also been made to provide for further possible shrinkages and adjustments in the inventories.

Property and plant account show an increase over the previous year of $9,361,000. The amount of unfilled orders on hand April 1, 1921, was $65,621,000.

During the year the position of the company in the radio electrical field was greatly strengthened by the acquisition of exclusive rights under the important patents owned by the International Radio Telegraph Co. These rights, together with others already owned, placed the Westinghouse Co. in a favorable position to develop and manufacture apparatus in a field that presents great future possibilities.

Book Reviews

THE BOILER BOOK, which has been compiled by H. E. Dart, superintendent of the Engineering Department of the Hartford Steam Boiler Inspection and Insurance Co., is, as explained in the preface, not intended as a treatise on boiler design but merely as a collection, in convenient form, of data which has been found valuable in the engineering department. It is published in loose leaf form so that its contents may be added to from time to time by subsequent issues of data sheets.

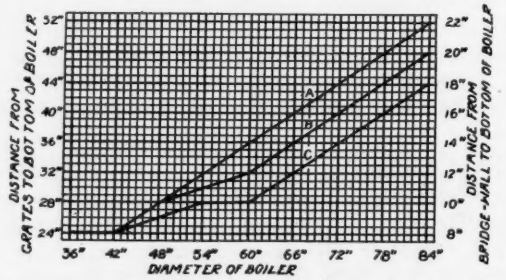
The data given includes dimensions and efficiencies of double, triple and quadruple riveted butt joints and of single and double riveted lap joints; allowable working pressures on cylindrical shells; and arrangements of tubes and braces in horizontal return tubular boilers. A method is described for finding the area to be stayed in heads of horizontal return tubular boilers. Correct proportions of through and diagonal stays and stay bolts are given. Two charts are presented, giving allowable working pressures on unstayed circular furnaces, one for lengths exceeding 120 times the plate thickness and one of lengths under this amount.

Considerable space is devoted to proportions of boiler settings and to dimensions of safety valves.

A chart, which we have here reproduced, gives recommended heights from grates to shell and from bridge wall to shell for horizontal return tubular boiler settings with different kinds of coal, for hand-fired settings with rates of combustion not to exceed 25 lb. of coal per square foot of grate surface per hour. Three kinds of coal are considered: A, bituminous, containing more than 35 per cent volatile matter (Illinois), B, bituminous containing from 18 to 25 per cent volatile (Pittsburgh), and C, anthracite and semi-bituminous, containing less than 18 per cent volatile (Pocahontas).

All of the material given is compatible with the A. S. M. E. boiler code rulings and some of it is taken from that source.

The editors are desirous of keeping this book up to date and of making it complete and to this end solicit suggestions for material that should be included in such a reference.


DISTANCE FROM GRATES TO BOTTOM OF BOILER
DISTANCE FROM BRIDGE-WALL TO BOTTOM OF BOILER
DIAMETER OF BOILER
32" 48" 44" 40" 36" 32" 28" 24"
22" 20" 18" 16" 14" 12" 10" 8"
36" 42" 48" 54" 60" 66" 72" 78" 84"
A
B
C

A-FOR BITUMINOUS COALS CONTAINING MORE THAN 35% VOLATILE MATTER. (ILLINOIS)
B-FOR BITUMINOUS COALS CONTAINING FROM 18% TO 35% VOLATILE. (PITTSBURGH)
C-FOR ANTHRACITE COAL AND SEMI-BITUMINOUS COAL, CONTAINING LESS THAN 18% VOLATILE. (POCAHONTAS, GEORGES CREEK, ETC.)

RECOMMENDED HEIGHTS FROM GRATES TO SHELL AND FROM BRIDGE WALL TO SHELL FOR HORIZONTAL TUBULAR BOILER SETTINGS WITH DIFFERENT KINDS OF COAL

ELECTRIC WELDING, by Ethan Viall; 417 pages, 329 illustrations, first edition, cloth; New York, 1921.

It is very evident that no time or pains were spared in the endeavor to make this one of the most comprehensive books on electric welding equipment and practice ever published. It is written in an excellent manner and the many illustrations of all types of electric welding equipment and work done, as well as the illustrations relating to theoretical and metallurgical considerations make it valuable to both the reader seeking general information and those engaged in the practice, research or development of electric welding.

Beginning with Chapter I, the subjects treated are as follows: Electric Welding—Historical, Arc Welding Equipment, Different Makes of Arc Welding Sets, Training Arc Welders, Carbon-Electrode Arc Welding and Cutting, Welding Procedure, Welding Terms and Symbols, Examples of Arc-Welding Jobs, Physical Properties of Arc-Fused Steel, Metallography of Arc-Fused Steel, Automatic Arc Welding, Butt-Welding Machines and Work, Spot-Welding Machines and Work, Welding Boiler Tubes by the Electric Resistance Process, Electric Welding of High-Speed Steel, Electric Seam Welding, Making Proper Rates for Welding and the Strength of Welds.

In the arranging of the material used in the book, particular care has been taken to classify and place

various subjects together as far as possible. This is not only convenient for reference purposes, but enables the reader easily to compare different makes and types of apparatus. In most cases, the name of the maker of each piece of apparatus is mentioned in the description in order to save the time of those seeking information.

Every possible source of information seems to have been drawn upon and the book should prove a permanent record of the electric welding art as it is today.

Trade News

THE POWER SPECIALTY CO. has for some time been conducting an investigation into the requirements of oil-heating apparatus in refinery work, with a view to developing a more efficient type of still and has recently published results of the investigations in a 40-page bulletin, in which are included descriptions of oil-heating apparatus which have produced highly satisfactory results, drawings of successful installations, a discussion of the flow of fluids in pipe lines, and curves, tables and other data of interest to refinery engineers and superintendents.

BULLETIN C2, a revised edition of Combustion Engineering Corporation's old Coxe stoker catalog, with supplementary text and revised line drawings, has just been received. This catalog contains description and illustrations of the Coxe stoker, primarily designed to handle the finer sizes of anthracite, but having, in recent years, demonstrated its ability to burn many grades of coal that were heretofore not even thought of as practical fuels.

A pamphlet from the same company contains a verbatim report of the speech, presented before the Engineers' Society of Western Pennsylvania, relative to its pulverized fuel installation under the largest boilers in the world at the Ford Motor Co.'s plant, Detroit, and all of the discussion relative to pulverized coal that followed.

Another pamphlet contains a report of a test conducted at the Oneida Street plant of the Milwaukee Electric Railway & Light Co., which was one of the first large public utility plants to be equipped with powdered coal.

TO MEET the insistent demands from busy men in every branch of industry for information as to the possibilities of usefulness of automatic counting machines, The Root Co., Bristol, Conn., has had compiled a very complete book, called "The Census Takers of Industry," which is replete with suggestions and abundantly illustrates the versatility of these little machines in their ability to remove the human element from counting operations.

CATALOG No. 58 of the Lunkenheimer Co., Cincinnati, O., contains 572 pages on valves, lubricators, pumps, boiler mountings, injectors and ejectors, and other Lunkenheimer specialties, also tables and useful data.

YARNALL-WARING CO.'S Bulletin R-1401 explains the recent development of the Yarway balanced control valve in both angle and globe patterns, with several forms of operating mechanisms. Descriptive matter relating to this valve may be obtained on application to the company at Chestnut Hill, Philadelphia, Pa.

REILLY EVAPORATOR, self-scaling, submerged type, described in The Griscom-Russell Co.'s Bulletin No. 330, is constructed with cast-iron, steel, copper or composition shell, depending upon the requirements. Illustrations indicate results secured in operation from the expansion movement of the coils with changes in temperature, a movement exaggerated by the Reilly coil.

A NEW CATALOG from The Frederick Engineering Co., Frederick, Md., discusses the construction of the Frederick underfeed stoker, "central station" and "super station" type, which, although of the general type of inclined, multiple retort, has many distinguishing features. Some typical installations are illustrated and general information is supplied which forms valuable data for preliminary layouts.

BULLETIN 801, recently issued by the Fulton Iron Works Co., takes up the design and operating characteristics of the Diesel engine and describes the important details of construction of the engine as manufactured by this company. The economic advantages of Diesel engine operation are discussed both from practical and theoretical considerations. The bulletin is handsomely prepared and is well illustrated with photographs and diagrams.

FULLER PULVERIZED COAL EQUIPMENT FOR LOCOMOTIVES is the title of Bulletin No. 700, issued by the Fuller Engineering Co., in which are described various adaptations of pulverized coal firing apparatus to locomotive practice. The equipment consists of four principal parts, the tank base and feed screws, the feeder casing, the feeder engine, and the turbine driven fan, each being described in more or less detail. A comparison is made between the costs of firing by hand, with mechanical stokers and using pulverized coal, and the possibilities of burning lower grade fuels by the last method are discussed. At the end a section is devoted to the description of a typical pulverizing plant.

THE UNITED STATES Bureau of Mines announces the issuance of Technical Paper 254, "The analysis of sulphur forms of coal," by Alfred R. Powell, organic chemist. This paper describes and elaborates the method for the determination of the various forms of sulphur in coal as originally outlined by the author while working with Prof. S. W. Parr at the University of Illinois. The method, which at that time was found to be applicable to Illinois coals, is shown by the results of the present investigation to be accurate when applied to coals from widely different fields. Certain changes and optional methods of procedure are suggested which it is hoped will make the method conform better to routine and rapid commercial analysis. Copies of Technical Paper 254 may be obtained by applying to the director of the Bureau of Mines, Washington, D. C.

NORDBERG DIESEL ENGINE is the title of a new 28-page, 8 by 10½ in. descriptive booklet, known as Bulletin No. 31, which is being distributed by the Nordberg Manufacturing Co. of Milwaukee. Photographic and diagrammatic illustrations are used to show the three types and important features of Nordberg Diesel engines. A number of the installation views show these engines driving generators and air compressors. The booklet gives considerable space to the fuel oil situation, the requirements of a Diesel engine, and the principle of the two-

cycle engine. It then points out the distinct features of the Nordberg engine, describes the different types and parts, and gives information relative to fuel consumption, speed regulation, auxiliary equipment, cooling water, and operation at high elevation. Copies of this new book may be had by addressing the company at Milwaukee.

BULLETIN No. 223 of W. S. Rockwell Co., 50 Church St., New York, illustrates various types of burners for the use of oil and gas fuels for industrial heating. Emphasis is laid on the fact that the real question is not alone one of burner selection, but rather the successful conduct of a heating or heat-treating operation as measured by the cost of production of a quality product. Features are the real "efficiency" of a burner; the selection of type and size to suit nature and pressure of fuel and atomizing element; methods of attaching burner plates; prices of different sizes in each type of burner; a chart showing the comparative cost per million B.t.u. at unit prices.

COMMERCIAL POSSIBILITIES of the Union of South Africa is the title of a pamphlet, the material of which has been assembled by the National Foreign Trade Council and summarized in brief form, in order to bring to the attention of American exporters a few of the most suggestive facts bearing on conditions in South Africa. Copies of this book may be obtained free, on request of O. K. Davis, Secretary, National Foreign Trade Council, 1 Hanover Square, New York City.

A NEW PUBLICATION of Chicago Pneumatic Tool Co., New York, entitled BQ—46 Hammer Drill, refers to several unique applications of this outfit which is adapted primarily to demolition work, as in removing surface pavement in laying conduit for telephone and lighting circuits and in construction of gas and water mains; in steel mills and glass plants for removing slag from ladles and slag pockets, glass from furnaces, etc.; and for many other purposes.

TYPE F Automatic Starters for Squirrel-Cage Induction Motors is the title of Leaflet 1660-A, which is being circulated by the Westinghouse Electric & Manufacturing Co. These starters are the transformer type of 400 hp. rating, 22 v. maximum; and the resistance type, 35 hp., 550 v. maximum. The leaflet illustrates the use of the gage type pressure regulator, the enclosed type float switch, the diaphragm pressure regulator and the push button station.

A BOOKLET relating to Metallo gaskets was recently received from Metallo Gasket Co., New Brunswick, N. J.

MANISTEE IRON WORKS CO.'s Bulletin No. 101, illustrating centrifugal pumps, rotary jet condensers, and rotary jet vacuum pumps was lately received.

LIQUID FUEL BURNERS for open hearth and other regenerative furnaces are illustrated and described in Bulletin LF-101, from The George J. Hagan Co., Pittsburgh, Pa.

ASH REMOVAL EQUIPMENT is the title of a pamphlet recently issued by Gillis & Geoghegan, of New York City, explaining and illustrating the installation and use of several auxiliaries used in connection with telescopic hoists.

A NEW Lunkenheimer booklet descriptive of the company's "Ferrenewo" valves, in which a special ferrous material is skillfully adapted to the smaller sizes of valve bodies, was lately received.

IN CATALOG S-21 of The Direct Separator Co., Inc., Syracuse, N. Y., are described and illustrated Sweet's steam separators, oil separators, combination steam and oil separators, and exhaust heads. Reports of tests of Sweet's separators are also given.

FORM No. 101, superseding Form 100 and dealing with Pennsylvania air compressors and reciprocating dry vacuum pumps, power and steam driven, straight-line, single-stage types, has just been received from Pennsylvania Pump & Compressor Co., Easton, Pa.

NORDBERG MANUFACTURING CO. has recently issued Bulletin No. 31, describing Nordberg Diesel engines, 200 to 4000 b.hp. The requirements, the advantages and the principle of operation are briefly discussed in the first pages of the bulletin, while details of construction are taken up in the latter part. The reading matter is well illustrated with numerous cuts and diagrams.

CURTIS STEAM TURBINES of 100 to 3500-kw. capacity have been developed for driving 60-cycle generators at 3600 r.p.m., according to Bulletin No. 42,201-B, issued by the General Electric Co., superseding Bulletin No. 42,201-A. This bulletin is generously illustrated by photographs of typical installations. An outline of the turbine principle as well as a detailed description of the construction features will be found in this instructive publication.

THE COMMERCIAL annular ball bearing, described in Catalog No. 6 of The Schatz Mfg. Co., Poughkeepsie, N. Y., is composed of an inner race ring, a set of hardened steel balls, two outer race rings, and a case closed over them, making the bearing a self-contained, non-adjustable unit.

TECHNICAL PUBLICATIONS of the U. S. Bureau of Standards which have recently been published for distribution are as follows: National safety code for protection of heads and eyes of industrial workers; progress report of National Screw Thread Commission; effect of the rate of cooling on magnetic and other properties of an annealed eutectoid carbon steel; effect of repeated reversals of stress on double-reinforced concrete beams; notes on small flow meters for air, especially orifice meters.

UNDER THE TITLE "Industrial Haulage," the General Electric Co. has issued an attractive illustrated bulletin, No. 44,251, in which are described some of the most representative types of electric locomotives which have been successfully used in a wide variety of industries. The list of industries covered comprises shipyards, steel plants, byproduct coke plants, ore docks, chemical plants, brick yards, stone quarries, cement plants, docks and warehouses, power house ash handling, and manufacturing plants in general.

The locomotives illustrated are of the trolley, third-rail, storage battery, and combination trolley and storage battery types. In construction, they are of the single or double truck type, and standard sizes vary in weight from 4 to 50 or more tons.